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February 2000

RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE

Volume 1 - Defense Advanced Research Projects Agency

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DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
61101E	CCS-02	INFORMATION SCIENCES	12.184	19.200	38.386	40.593	40.700	40.700	45.700
	ES-01	ELECTRONIC SCIENCES	19.662	21.761	17.498	19.743	22.645	30.506	36.365
	MS-01	MATERIALS SCIENCES	25.523	26.647	34.531	33.927	31.053	25.053	14.053
	61101E	**DEFENSE RESEARCH SCIENCES**	**57.369**	**67.608**	**90.415**	**94.263**	**94.398**	**96.259**	**96.118**
62110E	**NGI-01**	**NEXT GENERATION INTERNET**	**41.919**	**36.473**	**15.000**	**0.000**	**0.000**	**0.000**	**0.000**
62301E	ST-01	JASONS	1.188	1.193	1.200	1.200	1.200	1.200	1.200
	ST-11	INTELLIGENT SYSTEMS & SOFTWARE	78.512	73.038	91.524	74.403	60.536	72.393	68.034
	ST-19	HIGH PERFORMANCE & GLOBAL SCALE SYS	156.140	163.602	149.295	114.852	132.838	134.055	145.743
	ST-22	SOFTWARE ENGINEERING TECHNOLOGY	16.345	17.133	17.965	18.499	19.300	19.300	19.300
	ST-24	INFORMATION SURVIVABILITY	56.915	65.682	92.802	98.738	105.800	104.500	110.000
	ST-28	ASYMMETRIC THREAT	0.000	0.000	23.806	40.087	35.700	24.500	20.000
	62301E	**COMPUTING SYS & COMM TECHNOLOGY**	**309.100**	**320.648**	**376.592**	**347.779**	**355.374**	**355.948**	**364.277**
62302E	AE-01	DEEPLY NETWORKED SYSTEMS	0.000	5.405	13.513	12.860	25.000	30.000	42.000
	AE-02	SOFTWARE FOR AUTONOMOUS SYSTEMS	0.000	16.873	17.171	44.851	35.000	32.000	33.000
	AE-03	SOFTWARE FOR EMBEDDED SYSTEMS	0.000	7.722	23.821	27.700	12.000	15.000	10.000
	AE-04	GIGABYTE APPLICATIONS	0.000	0.000	14.777	19.785	18.000	13.000	10.000
	62302E	**EXTENSIBLE INFORMATION SYSTEMS**	**0.000**	**30.000**	**69.282**	**105.196**	**90.000**	**90.000**	**95.000**
62383E	**BW-01**	**BIOLOGICAL WARFARE DEFENSE**	**84.009**	**131.705**	**162.064**	**160.180**	**169.000**	**189.000**	**205.000**

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PE	PROJ	TITLE	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
62702E	TT-03	NAVAL WARFARE TECHNOLOGY	19.170	14.582	0.000	0.000	0.000	0.000	0.000
	TT-04	ADVANCED LAND SYSTEMS TECHNOLOGY	33.347	27.641	21.972	23.319	43.348	39.162	35.144
	TT-05	ADVANCED TARGETING TECHNOLOGY	0.000	0.000	0.000	6.400	5.700	14.700	26.200
	TT-06	ADVANCED TACTICAL TECHNOLOGY	45.918	34.558	32.232	43.028	45.673	41.530	41.371
	TT-07	AERONAUTICS TECHNOLOGY	30.163	40.748	29.131	20.475	32.593	42.450	47.291
	TT-10	ADVANCED LOGISTICS TECHNOLOGY	20.106	15.296	27.791	23.564	23.800	23.800	24.300
	TT-11	JOINT LOGISTICS ACTDS	10.249	9.676	9.925	9.893	0.000	0.000	0.000
	62702E	**TACTICAL TECHNOLOGY**	**158.953**	**142.501**	**121.051**	**126.679**	**151.114**	**161.642**	**174.306**
62708E	**IC-03**	**INTEGRATED COMMAND & CONTROL TECH**	**38.315**	**38.126**	**31.761**	**0.000**	**0.000**	**0.000**	**0.000**
62712E	MPT-01	MATERIALS PROCESSING TECHNOLOGY	165.443	126.110	126.759	130.031	142.472	140.554	140.395
	MPT-02	MICROELECTRONIC DEVICE TECHNOLOGIES	82.626	87.849	100.783	85.229	64.858	70.215	80.556
	MPT-06	CRYOGENIC ELECTRONICS	17.553	28.308	22.270	15.007	7.945	7.802	9.643
	MPT-07	MILITARY MEDICAL/TRAUMA CARE TECH	2.973	0.000	0.000	0.000	0.000	0.000	0.000
	62712E	**MATERIALS & ELECTRONICS TECHNOLOGY**	**268.595**	**242.267**	**249.812**	**230.267**	**215.275**	**218.571**	**230.594**
63285E	**ASP-01**	**ADVANCED AEROSPACE SYSTEMS**	**0.000**	**17.071**	**26.821**	**32.700**	**40.000**	**40.986**	**43.986**

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63739E	MT-03	UNCOOLED INTEGRATED SENSORS	12.803	10.732	11.916	6.930	0.000	0.000	0.000
	MT-04	ELECTRONIC MODULE TECHNOLOGY	61.437	55.153	43.684	45.772	48.067	38.029	36.829
	MT-05	TACTICAL INFORMATION SYSTEMS	31.519	20.668	0.000	0.000	0.000	0.000	0.000
	MT-06	MICROWAVE & ANALOG FRONT END TECH	3.809	0.000	0.000	0.000	0.000	0.000	0.000
	MT-07	CENTERS OF EXCELLENCE	6.062	5.478	4.000	0.000	0.000	0.000	0.000
	MT-08	MANUFACTURING TECHNOLOGY APPL	20.685	18.564	0.000	0.000	0.000	0.000	0.000
	MT-10	ADVANCED LITHOGRAPHY	48.026	44.791	45.012	45.013	45.000	44.000	45.000
	MT-12	MEMS & INTEGRATED MICROSYSTEMS TECH	75.955	74.711	37.712	37.590	24.000	24.025	10.825
	MT-15	MIXED TECHNOLOGY INTEGRATION	0.000	22.291	49.476	52.959	56.800	57.300	57.300
	63739E	**ADVANCED ELECTRONICS TECHNOLOGY**	**260.296**	**252.388**	**191.800**	**188.264**	**173.867**	**163.354**	**149.954**
63747E	**EV-01**	**ELECTRIC VEHICLES**	**9.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63760E	CCC-01	COMMAND & CONTROL INFORMATION SYS	82.299	100.583	79.209	92.557	104.234	109.534	117.234
	CCC-02	INFORMATION INTEGRATION SYSTEMS	89.071	85.343	49.654	38.131	32.246	34.512	35.837
	63760E	**COMMAND, CONT'L & COMMUNICATION SYS**	**171.370**	**185.926**	**128.863**	**130.688**	**136.480**	**144.046**	**153.071**
63761E	CST-01	ADVANCED SIMULATION	24.596	0.000	0.000	0.000	0.000	0.000	0.000
	CST-02	GLOBAL GRID COMMUNICATIONS	25.421	0.000	0.000	0.000	0.000	0.000	0.000
	63761E	**COMMUNICATION & SIMULATION TECH**	**50.017**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63762E	SGT-01	GUIDANCE TECHNOLOGY	32.868	19.866	22.173	22.199	32.964	33.514	36.564
	SGT-02	AEROSPACE SURVEILLANCE TECHNOLOGIES	60.204	40.722	61.545	78.838	88.232	90.550	109.300
	SGT-03	AIR DEFENSE INITIATIVE	24.430	38.141	24.301	19.667	30.000	37.750	38.200
	SGT-04	SENSORS & EXPLOITATION SYSTEMS	81.943	78.869	74.206	82.720	78.286	92.582	92.832
	63762E	**SENSOR & GUIDANCE TECHNOLOGY**	**199.445**	**177.598**	**182.225**	**203.424**	**229.482**	**254.396**	**276.896**
63763E	**MRN-02**	**MARINE TECHNOLOGY**	**24.779**	**21.681**	**30.304**	**38.257**	**54.896**	**59.696**	**70.496**

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PE	PROJ	TITLE	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63764E	LNW-01	RAPID STRIKE FORCE TECHNOLOGY	43.870	52.955	38.129	19.992	6.500	32.500	27.000
	LNW-02	SMALL UNIT OPERATIONS	41.417	43.365	35.120	47.675	32.600	41.500	45.000
	LNW-03	FUTURE COMBAT SYSTEMS	0.000	0.000	61.000	90.000	122.000	62.000	15.000
	63764E	**LAND WARFARE TECHNOLOGY**	**85.287**	**96.320**	**134.249**	**157.667**	**161.100**	**136.000**	**87.000**
63765E	**CLP-01**	**CLASSIFIED**	**48.797**	**78.973**	**101.387**	**103.795**	**89.100**	**65.000**	**55.000**
65114E	**BL-01**	**BLACKLITE**	**4.985**	**4.994**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**
65502E	**SB-01**	**SMALL BUSINESS**	**42.839**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
65898E	**MH-01**	**MANAGEMENT HEADQUARTERS (R&D)**	**32.898**	**32.103**	**34.679**	**35.954**	**37.276**	**38.400**	**38.542**
	AGENCY TOTAL		**1,887.973**	**1,876.382**	**1,951.305**	**1,960.113**	**2,002.362**	**2,018.298**	**2,045.240**
	BA-01	**TOTAL**	**57.369**	**67.608**	**90.415**	**94.263**	**94.398**	**96.259**	**96.118**
	BA-02	**TOTAL**	**900.891**	**941.720**	**1,025.562**	**970.101**	**980.763**	**1,015.161**	**1,069.177**
	BA-03	**TOTAL**	**848.991**	**829.957**	**795.649**	**854.795**	**884.925**	**863.478**	**836.403**
	BA-06	**TOTAL**	**80.722**	**37.097**	**39.679**	**40.954**	**42.276**	**43.400**	**43.542**
	AGENCY TOTAL		**1,887.973**	**1,876.382**	**1,951.305**	**1,960.113**	**2,002.362**	**2,018.298**	**2,045.240**

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R-1 #2					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	57.369	67.608	90.415	94.263	94.398	96.259	96.118	Continuing	Continuing
Information Sciences CCS-02	12.184	19.200	38.386	40.593	40.700	40.700	45.700	Continuing	Continuing
Electronic Sciences ES-01	19.662	21.761	17.498	19.743	22.645	30.506	36.365	Continuing	Continuing
Materials Sciences MS-01	25.523	26.647	34.531	33.927	31.053	25.053	14.053	Continuing	Continuing

(U) Mission Description:

(U) The Defense Research Sciences Program Element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term improvements through the discovery of new phenomena and the exploration of the potential of such phenomena for national security applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic and materials sciences.

(U) The Information Sciences project supports basic scientific study and experimentation in information sciences technology areas such as computational models, new mechanisms for performing computation and communication integrating biological and information processes, innovative approaches to the composition of software, and novel human computer interface technologies. At the intersection of biology and information technology, this project will explore scientific study and experimentation emphasizing biological software, computations based on biological materials, physical interfaces between electronics and biology, and interactive biology.

(U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) a substantial increase in performance and cost reduction of military systems providing these capabilities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R-1 #2

(U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; medical pathogen countermeasures; materials and measurements for molecular-scale electronics; spin-dependent materials and devices; advanced thermoelectric materials for cooling and power generation; and novel propulsion concepts.

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	64.429	64.293	68.792
Current Budget	57.369	67.608	90.415

(U) Change Summary Explanation:

FY 1999	Decrease reflects SBIR reprogramming and realignment of program priorities.
FY 2000	Increase reflects net effect of congressional adds for nanoelectric research and spectral hole burning and the government-wide rescission.
FY 2001	Increase reflects additional funding in Project CCS-02 for the Bio Futures program and expansion of molecular electronics, nanoscale/biomolecular materials and spin-dependent materials and devices efforts in Project MS-01.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2000		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Information Sciences CCS-02	12.184	19.200	38.386	40.593	40.700	40.700	45.700	Continuing	Continuing

(U) Mission Description:

(U) This project supports scientific study and experimentation that is the basis for more advanced knowledge and understanding in information sciences technology areas related to long-term national security requirements such as computational models and new mechanisms for performing computation and communication integrating biological and information processes. This project is also exploring innovative approaches to the composition of software and novel human computer interface technologies.

(U) In the area of Bio Futures, the combination of biology with information technologies and physical systems will open a new field of incredible potential. These technical fields have reached a capability level where the combination can enable both fundamental and applications breakthroughs. Progress in biology will be greatly aided by the ability to understand and manipulate the massive data inherent in living systems. Microelectronics and sensors have reached the level of systems sophistication and miniaturization that they can directly interface with biological cells. The fields of biological science and technology offer an understanding of systems complexity and robust operation using fundamental unreliable components, understanding that will enable new approaches for information technology, computers, and electronics.

(U) The Bio Futures effort will support scientific study and experimentation, emphasizing biological software, computation based on biological materials, physical interfaces between electronics and biology, and interactive biology. It will also apply information technology to accelerate the analysis and synthesis of biological processes by applying statistical language modeling tools to the problems of rapid bio-sequencing. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes and accelerated discovery of gene expression and protein-protein interactions. The Bio Futures program will also support the extraction of genetic circuit data from gene chips with the goal of determining the functioning of protein expression, protein interaction and cellular function. The applications of this will be to develop techniques using information theory for rational medical drug discovery and broad-spectrum antibiotics discovery for pathogens confronting the warfighter.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) Advances in cognitive neuroscience make it possible for us to be able to interface biological systems with computer systems. In turn these will be used to develop new modalities of human computer interfaces including augmentation of memory and spatial reasoning capabilities. In the area of human computer interfaces the project will study information management, interface technologies and their relationship to cognitive processes.

(U) Ubiquitous Computing and Human Computer Interfaces will explore information technologies that are not in the domain of traditional information sciences, for example: creation of a new programming language suitable for teaching computer users, without previous programming experience; the fabrication of inorganic semiconductor transistors and logic units by printing; development of handheld communication and computer devices that users can interact with through speech and vision cueing without using standard keyboard entry. Ubiquitous Computing and Human Computer Interfaces will develop information technologies for an environment where we are surrounded by computers which interact with us in mobile, intuitive fashion and enable collaborations as well as intelligent exchange of information in a seamless fashion. Architectures for nomadic software, redesigns of classical notions of operating systems of computers, secure exchange of information over insecure channels are some of the technical challenges in this area. Database currency and management of dynamically changing world views is another important area of research in pervasive computing.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Biological Computing. ($ 4.242 Million)
  - Demonstrated and validated computing models, with emphasis on DNA-based logic operations and cell-based computation.
  - Investigated novel control mechanisms for self-organizing and autonomous systems.

- Human Computer Interfaces. ($ 7.942 Million)
  - Demonstrated human-computer interaction for crisis planning.
  - Investigated feedback-driven approaches to information management.
  - Validated low-power configurable architecture; developed supporting software; and demonstrated automated mapping of 500K elements.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) FY 2000 Plans:

- Biological and Amorphous Computing. ($ 11.676 Million)
  - Evaluate alternative approaches to DNA-based computing and identify the most promising research opportunities for enhancement and acceleration.
  - Explore mechanisms for sequencing of DNA-based computations.
  - Investigate the use of game theory, probabilistic methods, and amorphous computing in Information Technology (IT), for use in decision aids and time critical systems.
  - Engineer complex artificial systems and explore biological systems across different size scales using multi-disciplinary approaches.
  - Explore biological inspired algorithms and models for computation.
  - Investigate novel approaches to real-time biological instrumentation in support of interactive biology, including development of minimally invasive imaging tools for monitoring the state of ongoing biological experiments.

- Ubiquitous Computing and Human Computer Interfaces. ($ 7.524 Million)
  - Design and implement a prototype interactive programming environment for pervasive computing.
  - Develop architectural design for ubiquitous computing using mobile devices with multi-modal data entry.
  - Create a prototype Information Grid Room (IGR) that can provide invisible computing and data storage for a single user.

(U) FY 2001 Plans:

- BioFutures. ($ 30.446 Million)

  Biological and Amorphous Computing.
  - Demonstrate real-time multi-sensor imaging of cell processes in support of interactive biology.
  - Establish focused research initiatives at the interface between biology, engineering, and information sciences.
  - Demonstrate use of high resolution imaging technology and signal transduction to effect interactive control over simple biological systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

– Evaluate alternative approaches to the implementation of game theory, probabilistic methods, amorphous computing in decision tools and software development.

Bio:Info:Physical Systems Interface.
– Explore fault tolerant hardware architectures, software techniques with the ability to self-heal and reprogram adaptively.
– Demonstrate modeling and control of genetic circuits, expression of proteins, protein-protein interaction and cellular function for rational medical drug design.
– Develop new hybrid devices combining biological and artificial components scaling from molecular-scale to population level.
– Create biologically inspired algorithms and models for computation, possibly including systems of hybrid devices.
– Apply developments in biology, information science and materials science to dramatically improve the interactions of humans and systems.
– Explore elaborated Hidden Markov Model techniques for structural homology identification and sequence alignment in genetic circuits, and for protein expressions.
– Explore extraction-based data mining approach for discovery of intracellular protein interactions.

- Ubiquitous Computing. ($ 7.940 Million)
  – Design universal software controlled communication interfaces that adapt to changes in the network and the surrounding environment.
  – Define the architecture for the interaction of multiple wireless handheld computers with speech and video input to enable the establishment of collaborative spaces and seamless transfer of information sources.
  – Upgrade Intelligent Grid Room (IGR) to support multiple users in distributed sites.

(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 BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Electronic Sciences ES-01	19.662	21.761	17.498	19.743	22.645	30.506	36.365	Continuing	Continuing

(U) Mission Description:

(U) This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nanometer-scale probing, sensing and manipulation for ultra-high density information storage "on-a-chip", for nanometer-scale patterning, and for molecular level analysis and synthesis. These microinstruments for nanometer-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nanometer-scale structures, molecules and devices.

(U) This project is also concerned with coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components critical to enhancing the effectiveness of military platforms that enable warfighter capabilities for comprehensive awareness and precision engagement, and contribute to the continued advancement of Next Generation Internet capabilities. Topics to be researched include emitters, detectors, modulators and switches operating from infrared to ultra violet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Infrared Detector Materials. ($ 2.861 Million)
  - Established feasibility of new uncooled detector structures, including micro-machined arrays, thin film ferroelectrics and bolometric materials.

- Ultra-Electronics. ($ 4.641 Million)
  - Demonstrated programmable matched filters operating at gigahertz speed with substantially less power than silicon complimentary metal oxide semiconductor.
  - Demonstrated completely integrated molecular beam epitaxy growth systems that realized closed-loop control of atomic layer growth and quantum device structures.

- Ultra-Photonics. ($ 7.179 Million)
  - Identified the device properties limiting performance of vertical cavity lasers and demonstrated methods for controlling their output beam quality.

- Electro-Magnetic Interference Electronics. ($ 1.928 Million)
  - Integrated promising new elements of ultraelectronics, high power electronics, non-volatile memory and Electro-Magnetic Interference (EMI) electronics.
  - Addressed, evaluated and applied current EMI thrusts in smaller, lighter, more mobile information systems and highest performance components and systems.

- Mechanical Electronics. ($ 0.954 Million)
  - Initiated mechanical electronics development resulting in very high efficiency, low voltage Direct Current to Direct Current converters.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

- Terahertz Technology. ($ 2.099 Million)
  - Explored technologies for a region of the electromagnetic spectrum (300 Ghz to 10 Thz, 1 mm to 30 micrometer) that has previously been difficult to access using conventional technologies, in order to exploit opportunities in environmental sensing, upper-atmosphere imagery and covert satellite communications.

(U) FY 2000 Plans:

- Mechanical Electronics. ($ 1.888 Million)
  - Demonstrate the properties for mechanical switches that include device speed and current density scale and size, hysteretic behavior for non-volatile memory applications and reduction of threshold switching voltage to below 10V.

- Terahertz Technology. ($ 3.397 Million)
  - Continue to exploit the terahertz region of the electromagnetic spectrum by investigating the best semiconductor approaches to sources and detectors, identifying mission critical operation.
  - Investigate the feasibility of integrating these components to form a range of compact subsystems for applications in space-based communications, remote sensing, covert communications, and chem-bio detection.

- Microinstruments. ($ 10.809 Million)
  - Research new technology for diagnostic instruments to support, maintain and service the warfighter and military platforms.
  - Investigate new technology concepts that support high volume/low cost wearable and hand-held diagnostic instruments.
  - Explore microinstruments “on-a-chip” concepts that integrate sensors, electronics, storage, display and actuation.
  - Evaluate microinstruments that include fluid dispensing, fluid sensing, and fluid identification important for "in-the-field" medical, chemical/biological and equipment diagnostics and repair.

- University Opto-Centers. ($ 5.667 Million)
  - Establish university opto-centers that are focused on creating new capabilities for the design, fabrication and demonstration of chip-scale modules which integrate photonic, electronic and Microelectromechanical Systems (MEMS) based technologies. Identify university technology research goals and modality for facilitating access by industry to these technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) FY 2001 Plans:

- Terahertz Technology. ($ 3.772 Million)
  - Demonstrate, for the terahertz spectral region, the best semiconductor quantum-well approaches to sources, demonstrate semiconductor quantum-well detectors and identify system requirements to achieve space communications, upper-atmosphere imagery and close-operations covert communications.

- Microinstruments. ($ 1.816 Million)
  - Demonstrate a patterning microinstrument that writes a pattern of array of 50nm minimum - feature-size bits or pixels at a rate of $6cm^2$/sec over an area of $1cm^2$.

- University Opto-Centers. ($ 11.910 Million)
  - Demonstrate initial chip-scale integrated photonic, electronic and MEMS modules.
  - Identify the most compelling module DoD applications and measure level of industry commitment to adopt chip-scale integration approach.

(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 BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Materials Sciences MS-01	25.523	26.647	34.531	33.927	31.053	25.053	14.053	Continuing	Continuing

(U) Mission Description:

(U) This project is concerned with fundamental research leading to the development of high power density/high energy density mobile and portable power sources; advanced thermoelectric materials for cooling and power generation; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; materials and measurements for molecular-scale electronics; a new class of semiconductor electronics based on the spin degree of freedom of the electron, in addition to (or in place of) the charge; medical pathogen countermeasures; and novel methods for reducing drag in future generations of high-speed ships.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Portable Power. ($ 9.395 Million)
  - Optimized catalysts, membranes and separator plates for high energy density solid oxide and direct methanol fuel cells.
  - Conducted brassboard testing of compact, high performance 500W solid oxide fuel cells for portable power applications.
  - Demonstrated novel 500W thermophotovoltaic power sources based on advanced materials.

- Nanoscale/Biomolecular Materials. ($ 6.306 Million)
  - Demonstrated the applicability of nanostructural materials in defense applications such as armor, high strength fibers, coatings and electronics.
  - Explored novel concepts in biomolecular materials and interfaces.
  - Developed single molecules and nanoparticles that exhibit electronic functionality and measured their intrinsic electronic properties.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Pathogen Countermeasures. ($ 5.198 Million)
  - Determined mechanisms of disease causing (virulence) factors in pathogens of concern to the DoD.

- Thermoelectric Materials. ($ 3.712 Million)
  - Developed thin film cooler utilizing quantum well structures.

- Advanced Drag Reduction (Fast Ship). ($ 0.912 Million)
  - Conducted study to assess military utility and top-level system implications of high-speed heavy lift for future forces.
  - Conducted study to identify and assess different possible approaches for hydrodynamic drag reduction.

(U) **FY 2000 Plans:**

- Portable Power. ($ 5.000 Million)
  - Design, build and test novel portable power sources that operate directly on logistics fuels.
  - Demonstrate a small (~50W) proton exchange membrane fuel cell operating on several novel hydrogen sources.
  - Demonstrate the operation of a portable direct methanol fuel cell.

- Nanoscale/Biomolecular Materials. ($ 7.167 Million)
  - Explore novel processing schemes for the formation of nanoscale/biomolecular and spin-dependent materials, interfaces, and devices.
  - Explore the capabilities of quasicrystals, amorphous metals, meta-materials, carbon nanotubes, quantum dots, and other nanostructured/biomolecular materials for enhancing the structural and functional performance of defense systems.

- Molecular Electronics. ($ 7.880 Million)
  - Demonstrate that molecules can be chemically tuned into a desired electronic functionality.
  - Fabricate nano-wires that are electrically conductive and can be assembled into rows or columns of wires via self-assembly.
  - Demonstrate that molecular and/or nanostructured materials can perform a storage function that can be driven from one state to another by an external signal.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Advanced Drag Reduction (Fast Ship). ($ 3.000 Million)
  - Conduct integrated hydrodynamic model development at multiple scales to provide foundational theory for quantitative drag prediction and drag reduction prediction.
  - Commence laboratory-scale calibration and confirmation testing of initial model predictions.

- Nanoelectric Research. ($ 1.900 Million)
  - Continue molecular and quantum-dot cellular automata nanoelectric research.

- Spectral Hole Burning. ($ 1.700 Million)
  - Investigate the applications of spectral hole burning.

(U) FY 2001 Plans:

- Nanoscale/Biomolecular Materials. ($ 10.000 Million)
  - Demonstrate enhanced performance from materials and processes incorporating nanostructured components.
  - Demonstrate the use of quantum chemistry for the theoretical design of new nanoscale/biomolecular/multifunctional materials and structures.
  - Explore the interface between biological systems and abiotic surfaces.

- Spin-Dependent Materials and Devices. ($ 7.000 Million)
  - Demonstrate spin-polarized transport across ferromagnetic/semiconductor interfaces.
  - Optimize spin lifetime in semiconductor structures.
  - Demonstrate spin light emitting diode (spin-LED) and spin field effect transistor (spin-FET).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Molecular Electronics. ($ 13.531 Million)
  - Demonstrate that molecules and/or nanoparticles can self-assemble into functional, regular patterns.
  - Build and test a minimum 16-bit functional, reversible molecular memory sub-unit.
  - Build and test room temperature scalable logic gates using molecules.

- Advanced Drag Reduction (Fast Ship). ($ 4.000 Million)
  - Complete integrated hydrodynamic model development at multiple scales.
  - Complete laboratory-scale calibration and confirmation testing of initial model predictions.
  - Develop model-based performance predictions of different potential drag reduction techniques.
  - Commence laboratory-scale confirmation testing of drag reduction performance predictions.

(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 Next Generation Internet PE 0602110E, R-1 #8					
COST *(In Millions)*	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	41.919	36.473	15.000	0.000	0.000	0.000	0.000	0.000	N/A
Next Generation Internet NGI-01	41.919	36.473	15.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) The Next Generation Internet (NGI) initiative has three goals: (1) promote experimentation with the next generation of networking technologies; (2) connect universities and national laboratories with high speed networks that are 100 - 1000 times faster than today's Internet; and (3) demonstrate revolutionary applications that meet important national goals and missions. The principal agencies involved in this initiative are DARPA, NSF, NIST, NIH and NASA. These agencies will share in funding this research and development effort. The DARPA activity will be aimed at part of the first two goals. DARPA will demonstrate end-to-end network connectivity at 1+ gigabits-per-second for 10 or more NGI sites. The network technologies to be addressed include multi-gigabit broadband networks, guaranteed quality of service mechanisms, and integrated network management. These technologies will be demonstrated in NGI developed testbed environments for defense-specific applications. Robustness of applications built atop diverse logical and physical infrastructure will be ensured with the development of new software and hardware tools that can automatically track and assess the inter-dependencies of physical layer resources.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Gigabit-per-second Network Connectivity. ($ 27.019 Million)
  - Implemented 10 gigabit-per-second, multi-wave optically switched Wavelength Division Multiplexed (WDM) technology in NGI testbed.
  - Implemented an alpha-level prototype high-speed optical multiplexor and develop specification of Internet Protocol (IP)/WDM protocol structure.
  - Implemented prototype components of network monitoring and management system.

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 Next Generation Internet PE 0602110E, R-1 #8

- Network Management. ($ 14.900 Million)
  - Defined application program interfaces for information management and collaborative applications.
  - Executed regional partnerships for revolutionary applications.

(U) FY 2000 Plans:

- Gigabit-per-second Network Connectivity. ($ 17.000 Million)
  - Implement variable rate access technologies and prototype of distributed optical switching capability compatible with 100 Gb/s optical network.
  - Implement streamlined Internet over WDM protocol structure, eliminating two layers of existing telecommunications infrastructure.

- Network Management. ($ 19.473 Million)
  - Develop network planning and simulation technology to meet requirements for NGI scale networks.
  - Demonstrate real-time (500-msec response) monitoring and control of network resources at all levels.
  - Complete interconnection of Supernet testbed components and software with 2.5 gigabit-per-second access architecture, up to 10 gigabit-per-second backbone, and 100 Gb/s distributed switching capacity.
  - Demonstrate information management and collaborative applications operating over NGI testbed.

(U) FY 2001 Plans:

- Network Architecture and Management for Robust Heterogeneous Gigabit Networks. ($ 6.900 Million)
  - Develop architectural framework for ensuring maximum end-to-end system survivability.
  - Prototype tool for assessing dependence of applications or networking performance on physical layer resources.
  - Specify robust heterogeneous network architecture that integrates gigabit wireless, wireline and satellite communications.

- Defense Applications of Gigabit Networks. ($ 8.100 Million)
  - Develop virtual radar console tied to a physical radar and remotely accessible via wide-area network.
  - Demonstrate real-time, high-resolution imagery transfer over multiple streams of multi-gigabyte flows.

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 Next Generation Internet PE 0602110E, R-1 #8

– Enable streaming of raw (undigitized) sensor signal over wide-area links.

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	49.504	40.000	0.000
Current Budget	41.919	36.473	15.000

(U) Change Summary Explanation:

FY 1999 Decrease reflects Omnibus and SBIR reprogrammings and $5.000 Million transfer to OSD HPC Modernization (PE 0603755D) for the partnership between centers program.

FY 2000 Decrease reflects Congressional actions; partially offset by minor reprogramming.

FY 2001 Increase reflects decision to continue program one additional year to ensure orderly transition to private sector support and adequately demonstrate the military utility of NGI-developed technology.

(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, 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.

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

(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.

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-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.

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-01

(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.

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-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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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

(U) 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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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

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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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
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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.

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-11

- 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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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- 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.

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-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.

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-19

- 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.

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-19

- 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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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 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.

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-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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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22

- 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.

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-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.

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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 Extensible Information Systems PE 0602302E, R-1 #14				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	0.000	30.000	69.282	105.196	90.000	90.000	95.000	Continuing	Continuing
Deeply Networking Systems AE-01	0.000	5.405	13.513	12.860	25.000	30.000	42.000	Continuing	Continuing
Software for Autonomous Systems AE-02	0.000	16.873	17.171	44.851	35.000	32.000	33.000	Continuing	Continuing
Software for Embedded Systems AE-03	0.000	7.722	23.821	27.700	12.000	15.000	10.000	Continuing	Continuing
Gigabyte Applications AE-04	0.000	0.000	14.777	19.785	18.000	13.000	10.000	Continuing	Continuing

(U) Mission Description:

(U) This program is part of a multi-agency initiative to greatly extend the reach and effectiveness of networked computation. It is funded in the applied research budget activity because it is pursuing network and software research to facilitate the "deep networking" of computers, such as those embedded within DoD platforms and weapons. It will also conduct research to greatly increase the autonomy of those systems, so as to promote the human role from that of operator to supervisor.

(U) The Deeply Networked Systems project is developing the software for designing and managing a single complex system, which is composed of multiple sub-systems, and each sub-system has many embedded devices. The challenge is to network such devices that are located in different sub-system/components. Doing so will require a much “deeper” approach to information systems – one that manages the vast quantities of “physical” information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, both the network and embedded software infrastructure must be extended to deal with: challenges created by a wide diversity of embedded devices dealing in physical world information which must be addressed by network research; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients. Research on embedded software creation must radically extend the technology to enable the composition of software systems subject to physical constraints.

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(U) The Software for Autonomous Systems project develops software to enable reliable, safe, and cooperative operation of free ranging, autonomous systems. This effort includes software for mobile robots (air, land or maritime unmanned vehicles) performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, these autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro sensors that enable a new wave of DoD applications. For example, cheap, smart micro-sensors can be deployed quickly in large quantities in the battlefield to perform new monitoring and control functions; and a host of sensors can be attached to warfighters and assets to autonomously monitor safety and health information, and equipment condition. The Software for Embedded Systems project is developing the software for networking the untethered micro sensors in a relatively wide area environment, for example, a sensor net on the ground and water. A unique processing capability, collective processing, due to this networking environment will also be explored. This new class of software will deal with the processing of physical world information by networked embedded devices.

(U) The Gigabyte Applications project is developing the technology to enable robust operation of DoD's mission-critical systems and platforms that are inherently geographically dispersed and are dependent on extremely high data flows. Capabilities for end-applications to tie in with other applications as well as with signals from multiple hardware sources and with human users will be developed with technologies that allow ultra high-throughput, sustained low-latency data delivery and processing. Gigabyte to terabyte flow transfers across end applications will be demonstrated over wide-area networks. The project will also develop robust, survivable inter-networking architecture that will minimize vulnerability posed by the growing complexity and brittleness that is seen across physical layer networking architecture today.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	0.000	70.000	70.000
Current Budget	0.000	30.000	69.282

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(U) Change Summary Explanation:

FY 2000 Decrease reflects a Congressional program reduction and government-wide rescission, partially offset by minor program repricing.

FY 2001 Decrease reflects inflation adjustments.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01					
COST (In Millions)	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Deeply Networked Systems AE-01	0.000	5.405	13.513	12.860	25.000	30.000	42.000	Continuing	Continuing

(U) Mission Description:

(U) Extending DoD's ability to monitor and control the physical environment will require a much "deeper" approach to information systems – one that manages the vast quantities of "physical" information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, both the network and embedded software infrastructure must be extended to deal with: challenges created by a wide diversity of embedded devices dealing in physical world information which must be addressed by network research; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients. Research on embedded software creation must radically extend the technology to enable the composition of software systems subject to physical constraints.

(U) The large scale networking of embedded and autonomous devices creates new requirements for: embedded technologies that can achieve drastic reductions in costs while being compatible with a wide range of network and computation media; flexible mechanisms for naming, addressing, configuring and administering communication and computation resources; and system design technology which shifts the emphasis from static verification and validation to dynamic behavior guarantees. These challenges are addressed in the Networked Embedded Systems component of this project.

(U) Future defense uses of the network will have an increased emphasis on the direct exchange of real-time sensor-derived information among autonomous embedded devices. This reflects a significant change in network traffic from the present environment, which is dominated by the exchange of symbolic information among human users. The architectures and protocols needed to effect this transition will be investigated in the Networked Embedded Systems component of this project.

(U) Many applications of deeply networked systems will perform data dissemination and fusion operations that could most efficiently be performed at nodes within the network. The Networked Embedded Systems component of this project will leverage the capabilities of a programmable network substrate to deploy middleware that is nomadic in nature and can go where network connectivity permits. This capability will permit network elements to host services on behalf of embedded and autonomous devices.

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(U) Tight integration of information processing with physical processes demands new technology for the integrated modeling of software and physical systems. These models will enable designers to capture complex cross cutting physical constraints that the embedded software must satisfy. The Model-Based Integration of Embedded Software component of this project will use integrated models to analyze and verify the aggregate behavior of software and physical processes, and to automatically customize, integrate system components.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

(U) FY 2000 Plans:

- Networked Embedded Systems. ($ 5.405 Million)
  - Investigate new modeling methods capturing physical constraints in embedded systems such as avionics and vetronics.
  - Develop customizable modeling tools that can be rapidly adjusted to different modeling views and application domains.
  - Investigate new generation technology with capability to configure, customize and synthesize software directly from models.

(U) FY 2001 Plans:

- Model-Based Integration of Embedded Software. ($ 9.925 Million)
  - Develop modeling tools that can manage overlapping modeling views.
  - Investigate methods for the mathematical modeling and composition of model-based software generators.
  - Develop customizable frameworks for embedded software.
  - Demonstrate the rapid synthesis of embedded systems using customizable frameworks and model-based generators.

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- Networked Embedded Systems. ($ 3.588 Million)
  - Develop methods for maintaining and updating critical information (system and resource states, global time, etc.) system-wide, without centralized depository.
  - Investigate event/time triggered system synthesis methods subject to time, functional, performance, safety and security constraints.
  - Investigate design methods of embedded generators that guarantee selected behaviors of the generated 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 Extensible Information Systems PE 0602302E, Project AE-02					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software for Autonomous Systems AE-02	0.000	16.873	17.171	44.851	35.000	32.000	33.000	Continuing	Continuing

(U) Mission Description:

(U) This project develops software to enable predictable, safe, and cooperative operation of free ranging, autonomous systems. This effort includes software for mobile robots (air, land or maritime unmanned vehicles) performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, these autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) Autonomous systems will enable revolutionary, asymmetric military capabilities, such as the ability to autonomously convey military payloads (both lethal and non-lethal) to any portion of the battlefield without requiring human operators and the ability to autonomously retrieve, process and deliver information.

(U) The Common Software for Autonomous Robotics component of this project will develop a combination of critical, enabling software technologies that can be reused across a wide range of mobile autonomous robotic systems.

(U) The Software Enabled Control component will leverage increased processor and memory capacity to vastly increase our ability to maintain control over mobile devices through the development of novel techniques, such as: predictive mode changes, dynamic control scheduling, composable coordinated control, and dynamic sensor and actuator allocation.

(U) The Agent Based Negotiation component will enable the autonomous operation of large collections of agents negotiating resource allocation issues, such as those encountered in logistics and countermeasures.

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(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

(U) FY 2000 Plans:

- Common Software for Autonomous Robotics. ($ 6.734 Million)
  - Develop architectures for the integration of deliberative, reactive and learning behaviors, including knowledge representations.
  - Laboratory demonstration of alternative approaches to off-line learning.
  - Laboratory demonstration of rapid sensor-motor mapping.
  - Laboratory demonstration of "engineered" behaviors.
  - Laboratory demonstration of "statistical" control.

- Software Enabled Control. ($ 6.950 Million)
  - Specify architecture for a hybrid control system that synthesizes the control law approach with computationally-enabled mode logic scalable to very large state spaces of 100K+ states.
  - Develop active transition control and joint mode logic/control law designs.
  - Design services for active model creation, augmentation, and query.

- Agent Based Negotiation. ($ 3.189 Million)
  - Develop framework for bottom-up organization of autonomous software.
  - Define strategy for tasking and consolidation of responses from large numbers (thousands) of software agents with minimal human intervention.

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(U) FY 2001 Plans:

- Common Software for Autonomous Robotics. ($ 4.963 Million)
  - Experimental evaluation of networking protocols for distributed robot controls that are more energy efficient than conventional implementations.
  - Prototype demonstration and experimental evaluation of software for distributed robotics capable of coordinating the operation of 10+ robotic devices in a collective task.

- Software Enabled Control. ($ 9.727 Million)
  - Alpha-level prototype implementation of multi-mode control architecture and framework.
  - Develop predictive active model framework.
  - Develop parametric predictive and adaptive control frameworks.
  - Complete multi-level, multi-modal advanced design tools.

- Agent Based Negotiation. ($ 2.481 Million)
  - Prototype demonstration of autonomous software ability to utilize negotiation in logistics scenario.
  - Develop analysis strategy for predicting global behavior of large negotiating teams.

(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 Extensible Information Systems PE 0602302E, Project AE-03					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software for Embedded Systems AE-03	0.000	7.722	23.821	27.700	12.000	15.000	10.000	Continuing	Continuing

(U) Mission Description:

(U) This project develops a new class of software to deal with the processing of physical world information by networked embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro-sensors that enable a new wave of DoD applications. For example, cheap, smart micro-sensors can be deployed quickly in large quantities in the battlefield to perform new monitoring and control functions; and a host of sensors can be attached to warfighters and assets to autonomously monitor safety and health information, and equipment condition.

(U) Harnessing the full potential of micro-sensors and embedded devices requires addressing new information technology challenges. Networking these untethered devices creates new requirements on hardware and software, including rapid self-assembly, timely acquisition, processing and exchange of sensor data, and energy efficient operation. Accurate identification of events and collection of information require new ways of cooperation among these devices to process physical world signals, and to integrate information in the network. Additionally, remote querying and accessing data collected by the sensor net should be simple, with easy to use interfaces.

(U) This project will build on Software and Networking R&D activities, extending and specializing them to geographically distributed micro-sensor networks. A major challenge is the development of software technologies that spans a variety of sensor nets, on ground and water, on buildings and bodies. Another challenge is to design reliable networked embedded systems retaining only supervisory control, while automating traditional "in-the-loop" tasks. The sensor tasking, data collection, integration and analysis must be fully automated to enable operation within time constraints far shorter than could be achieved by human operators.

(U) As software systems become more complex, they must be able to reconfigure and evolve themselves dynamically, while the system is in operation. This project will develop the dynamic gauges or measures of composability necessary to enable software components from any source to support assured applications (Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA)). Outputs from this program will ensure that the critical properties of complex, heterogeneous software systems are maintained during and after composition, adaption and deployment.

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 Extensible Information Systems PE 0602302E, Project AE-03

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

(U) FY 2000 Plans:

- Large Scale Networks of Sensors. ($ 7.722 Million)
  - Specify diffusion based approaches to networking, and aggregation and distribution of information from large numbers of multi-taskable sensor nodes.
  - Explore low-latency system designs; develop experimental platform and simulation capability.
  - Develop methods for collaborative signal processing and information integration.
  - Investigate use of declarative interfaces for tasking and querying of networked embedded systems; develop experimental prototype based on relational database query technology and lightweight operating environment.

(U) FY 2001 Plans:

- Large Scale Networks of Sensors. ($ 16.873 Million)
  - Implement experimental prototype supporting automated aggregation and distribution of sensor derived information involving at least 50 nodes and 100 sensors.
  - Investigate methods for efficient interoperation of fixed and mobile sensors.
  - Implement networked detection, estimation, tracking, and information integration.
  - Demonstrate multi-node sensor network software and benefits of collaborative signal processing for military operations such as fast moving target detection and urban operations.
  - Prototype demonstration using declarative interfaces for tasking and querying of multi-taskable sensor networks.
  - Specify interfaces supporting common run-time services required by signal processing and generation applications.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03

- Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA). ($ 6.948 Million)
  - Conduct preliminary demonstrations of dynamic software component composability with multiple standard communication (e.g. Distributed Component Object Model (DCOM), Common Object Request Broker Architecture (CORBA), Distributed Computing Environment (DCE)) or structuring (e.g., Extended Markup Language (XML), Resource Description Framework (RDF), Document Object Model (DOM)) infrastructures.

(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 Extensible Information Systems PE 0602302E, Project AE-04					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Gigabyte Applications AE-04	0.000	0.000	14.777	19.785	18.000	13.000	10.000	Continuing	Continuing

(U) Mission Description:

(U) This project is developing the technology to enable robust operation of DoD's mission-critical systems and platforms that are inherently geographically dispersed and are dependent on extremely high data flows. Capabilities for end-applications to tie in with other applications as well as with signals from multiple hardware sources and with human users will be developed with technologies that allow ultra high-throughput, sustained low-latency data delivery and processing. Gigabyte to terabyte flow transfers across end applications will be demonstrated over wide-area networks. The project will also develop robust, survivable inter-networking architecture that will minimize vulnerability posed by the growing complexity and brittleness that is seen across physical layer networking architecture today.

(U) The efforts will leverage some of the advances made within earlier programs, such as the Next Generation Internet for high-speed communications and networking, but will largely target breakthroughs in DoD focused gigabyte applications, in gigabyte dataflows over wireless as well as wireline infrastructure, and in enhancing the robustness of these heterogeneous links and resources. Advances in architectural work and tools in ultra-high-performance heterogeneous flow-based communications will be pursued to enable a large number of end applications with extremely diverse traffic characteristics – expected for DoD supporting applications - to be simultaneously deployed. With the optical communications techniques that can now support many hundreds of Gigabits Per Second (Gbps) data transfer over terrestrial fiber cables, there exists today a huge bandwidth gap between wireless and wired link capability. In the Gigabit Multi-Link component of this project, new gigabit per second communication capabilities over alternate physical media will be demonstrated such that gigabyte flow transfers can be demonstrated to sites lacking in fiber infrastructure and connectivity. Multi-channel techniques in temporal, spatial, and spectral domains will be invoked to enable the new capabilities.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-04

(U) FY 2000 Plans:

- Not Applicable.

(U) FY 2001 Plans:

- Ultra-High Performance Heterogeneous Flow-Based Communications. ($ 7.300 Million)
  - Develop software and physical interfaces that can adapt or be programmed to support diverse link protocols, symbol rates and signaling technologies.
  - Demonstrate gateway technology that can segregate long flows from short flows.
  - Prototype implementation for transparent, vertical handoff between flow-based and circuit-based connectivities.

- Gigabit Multi-Link. ($ 7.477 Million)
  - Demonstrate an order of magnitude increase in wireless spectral efficiency for non-mobile end nodes.
  - Establish feasibility of 10 Gbps transmission over 10km free-space link.
  - Demonstrate adaptive multi-link coding technique to enhance immunity to degradations due to mobility or environmental (weather, obstruction) changes.

(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 Biological Warfare Defense PE 0602383E, R-1 #15					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	84.009	131.705	162.064	160.180	169.000	189.000	205.000	Continuing	Continuing
Biological Warfare Defense Program BW-01	84.009	131.705	162.064	160.180	169.000	189.000	205.000	Continuing	Continuing

(U) Mission Description:

(U) DARPA's Biological Warfare Defense program is budgeted in the Applied Research budget activity (BA-2) because its focus is on the underlying technologies associated with pathogen detection and remediation. Today, there is a tremendous mismatch between the magnitude of the biological warfare threat and the Department's ability to adequately respond. The widespread availability of bacterial, viral, toxin, and chemical stocks; minimal developmental cost and scientific expertise required; and abundance of weaponization potential comprises a sinister threat. The single largest concern, however, is from the exploitation of modern genetic engineering by adversaries to synthesize "super pathogens." Recent dramatic developments in biotechnology, which this program will leverage, promise to eliminate this mismatch. This program funds projects supporting revolutionary new approaches to biological warfare (BW) defense and does not duplicate efforts of other government organizations.

(U) Efforts to counter the BW threat include developing barriers to block entry of pathogens into the human body (including unique methods for rapid air and water purification), countermeasures to stop pathogen and chemical consequence and to modulate host immune response, medical diagnostics for the most virulent pathogens and their molecular mechanisms, biological and chemically-specific sensors, advanced decontamination and neutralization techniques, consequence management tools, and integrated defensive systems. Program development strategies include collaborations with pharmaceutical, biotechnology, government, and academic centers of excellence.

(U) Pathogen countermeasures (e.g., Anti-Virals/Immunizations, Anti-Bacterials/Anti-Toxins, Multi-Purpose, and External Protection) under development include: (1) multi-agent therapeutics against known, specific agents and (2) therapeutics against virulence pathways shared by broad classes of pathogens. Specific approaches include modified red blood cells to sequester and destroy pathogens or other toxic compounds, modified stem cells to detect pathogens and produce appropriate therapeutics within the body, identification of virulence mechanisms shared by pathogens, development of therapeutics targeting these mechanisms, efficacy testing in cell cultures and animals, and advanced non-toxic decontamination strategies.

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(U) In the early stages, many illnesses caused by BW agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics efforts will develop the capability to detect the presence of infection by biological threat agents, differentiate them from other significant pathogens, and identify the pathogen even in the absence of recognizable signs and symptoms (when the pathogen numbers are still low).

(U) The ability to rapidly detect biological warfare agents on the battlefield with a low false-alarm rate is a crucial requirement. To address this need, the program is creating more efficient and effective miniature sampling technologies that concentrate contaminated air and enhance the ability to capture biological warfare agents. The program is developing a new range of antibodies and "designer small molecules" to bind specific agents (to replace the lower affinity antibodies currently used). In order to detect that the binding of an agent has occurred, the event must be "magnified." Traditionally, this is done by tagging the antibody molecule with a fluorescent probe. This program is replacing the noise-plagued fluorescent tags with Up-Converting Phosphors with the sensitivity to detect a single binding event, minimizing the size of the sample required, saving time, and decreasing the number of false positive alarms. The use of fluids as a requirement for biological agent detection is also being eliminated and replaced by a miniaturized (shoe box-size) time-of-flight mass spectrometer. Development of a bacterial biochip to identify genus and species without multiplying the DNA by the polymerase chain reaction (PCR) is also under development, thereby saving at least 20 minutes in time to identification. Additional efforts are focusing on the construction of molecular, cellular, and multicellular sensors for the rapid detection of biological threats. These cellular and tissue-based sensors have the ability to respond to both known and unknown threats, determine live vs. inactivated threat status, and report functional consequences of exposure (mechanisms of action). The use of organisms such as insects are also being explored as information collectors for environmental biological or chemical threats. A variety of applications for these sensors are being explored including protection of buildings from a biowarfare agent attack.

(U) Mission effectiveness requires rapid, correct medical responses to biological weapon threats or attacks. This project will provide comprehensive protocols to protect or treat combatants by using current and emerging biological countermeasures. It will provide accelerated situational awareness for biological warfare events by detecting exposure to agents through an analysis of casualty electronic theater medical records and will locate and determine the most effective logistical support for providing appropriate treatment and pathogen-specific resources required to mitigate effects of the attack.

(U) DARPA is working with a number of governmental organizations to exploit recent advances in high throughput genetic sequencers to obtain complete genetic information on a number of important pathogens and their non-pathogenic nearest neighbors. This will allow us to develop

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an inventory of genes and proteins that distinguish pathogens from non-pathogens and to identify pathogenic markers in any guise. This information will be used to provide superior molecular targets and enable new generations of detectors, diagnostics, and therapeutics.

(U) DARPA is developing technologies for integrated defensive systems to be employed in buildings to protect inhabitants and enhance the capability to decontaminate exposed surfaces. In addition to advanced sensors, DARPA is pursuing low-pressure-drop filters, advanced decontamination and neutralization techniques, and fate and transport models to predict agent location and lethality.

(U) Lastly, DARPA is sponsoring a one-year investigation in FY 2000 of a technology that uses a new material (aerogel) for the collection of agents of biological origin. Aerogel is a term used to describe very low-density, highly porous, polymeric materials that provide a highly efficient, lightweight collection medium for airborne particles.

(U) **Program Accomplishments and Plans:**

(U) FY 1999 Accomplishments:

- Anti-Virals/Immunizations. ($ 14.820 Million)
  - Developed a modified stem cell, which can both detect and produce a prophylactic/therapeutic response to a pathogen (in cell culture).
  - Determined (in-vitro) toxicity of modified stem cell-produced therapeutics.
  - Created techniques to rapidly develop immunization strategies against bacterial and viral pathogens and toxins.

- Anti-Bacterials/Anti-Toxins. ($ 14.857 Million)
  - Developed and tested (in-vitro) cellular platforms for toxin destruction and toxin binding decoys.
  - Demonstrated selected strategies (in cell culture) to:
    Inhibit the expression of disease causing (virulence) factors by pathogens.
    Disrupt the disease causing (virulence) communications between pathogens.
    Modulate the body's response to the presence of a pathogen.

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- Multi-Purpose. ($ 12.000 Million)
  - Defined animal models in which to test the efficacy of modified stem cells to prevent disease.
  - Demonstrated in laboratory animals the efficacy of modified red blood cells to eliminate pathogens from the blood for the purpose of potential defense against biological warfare agents.
  - Determined pathogen detection and elimination efficacy for modified red blood cells with enzymes or other active molecules attached to their surfaces.

- External Protection. ($ 6.450 Million)
  - Developed polymeric materials for pathogen protection.
  - Demonstrated in-vivo broad-spectrum efficacy of non-toxic biological decontamination formulation.

- Advanced Diagnostics. ($ 10.900 Million)
  - Determined appropriate bodily sample types (blood, saliva, sputum, etc.) to use for diagnosis.
  - Determined which non-biological warfare (BW) pathogens must be screened against because they mimic early symptoms of known BW threat agents.
  - Began identification of probes to be used in diagnosis systems.
  - Evaluated the feasibility of novel technologies and sampling strategies, such as detecting bodily responses indicative of infection.

- Sensors. ($ 15.390 Million)
  - Continued development of air sampling technology for airborne biological materials.
  - Determined chemotaxonomic biomarkers for selected viral substances for detection in a mass spectrometer.
  - Demonstrated replacement of a surface-bound antibody with a “designer” small molecule for high affinity pathogen capture.
  - Developed a high affinity monoclonal antibody that recognizes only anthrax spores without cross-reactivity with vegetative cells (or other bacillus species) and tested in existing BW sensors for improved performance.
  - Completed Up-Converting Phosphors (UCP) detection system and field test.
  - Modified the prototype of a miniature biodetection system following Dugway Proving Ground test results.
  - Selected cell and tissue types for the development of tissue based sensors.

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- Examined and selected strategies to stabilize cell systems for long-term shelf life and functional response.
- Demonstrated the ability to modify the duty cycle of a cellular response in single cell and tissue based sensors.
- Demonstrated performance limits of a single cell sensor.

- Consequence Management. ($ 8.600 Million)
  - Developed prototype software toolkit for Enhanced Consequence Management Planning and Support System (ENCOMPASS).
  - Conducted field tests of BW defense attack response planning tools and Electronic Watchboard.
  - Developed Electronic Watchboard architecture and BW incident playbook authoring and maintenance tools.
  - Incorporated USAMRIID biological warfare agent treatment directives into playbooks and accelerated development of Biological Agent Symptom Information System (BASIS).

- Multimedia/Telemedicine. ($ 0.992 Million)
  - Developed an enhanced telemedicine capability for the warfighter by augmenting/tailoring wireless communication technologies appropriate for responses to biological warfare attacks.

(U) **FY 2000 Plans:**

- Anti-Virals/Immunizations. ($ 16.999 Million)
  - Identify broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.
  - Develop technologies for rapid design and development of new vaccines against novel pathogens.
  - Demonstrate (in-vitro) candidate anti-viral small molecule therapeutics for selected targets.
  - Demonstrate (in-vivo) the efficacy of anti-viral peptides derived from hematopoietic stem cells.

- Anti-Bacterials/Anti-Toxins. ($ 17.065 Million)
  - Develop (in-vitro) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Validate the efficacy (in-vivo) of antagonists to toxin receptors, toxin catalytic sites, and cellular platforms for toxin destruction.
  - Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial antagonist.
  - Use gene-shuffling techniques to generate molecules to be screened for superantigenic properties.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, R-1 #15

- Multi-Purpose. ($ 16.466 Million)
  - Explore concepts for therapeutics against bioregulators and other mid-spectrum agents.
  - Identify primary harmful immune responses to biological warfare (BW) agents.
  - Explore concepts for optimizing human immune response to BW agents, minimizing negative sequelae.
  - Demonstrate in laboratory animal models the ability of modified stem cells to prevent disease.
  - Identify monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
  - Identify polyvalent inhibitors for inhibiting pathogens on the surface of target cells in-vivo.

- External Protection. ($ 17.137 Million)
  - Develop decoy molecules that will prevent the adhesion of multiple pathogenic toxins or viruses in-vivo.
  - Demonstrate (in-vivo) a non-specific surfactant agent to neutralize biological threat agents.
  - Demonstrate initial performance of a prototype device for the purification of water contaminated with BW agent simulants.
  - Explore high throughput methods for the purification of contaminated air.
  - Demonstrate effectiveness of specific personnel protective toxin and pathogen neutralization strategies against virulent biological agents.

- Advanced Diagnostics. ($ 15.792 Million)
  - Continue identification and development of probes to be used in diagnosis systems, and begin testing of probe panels in the laboratory.
  - Develop sample preparation techniques to optimize speed, accuracy, and reliability of diagnosis.
  - Identify one or more promising strategies for rapid detection based on bodily responses or other biomarkers (including cytokines) to provide early indication of infection or exposure (including non-invasive early detection of disease [e.g., nitric oxide in exhaled breath]).
  - Determine feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Determine feasibility of rapid single molecule DNA sequencing for accelerated patient diagnosis.
  - Explore concepts for diagnosing patients for bio-regulator and other mid-spectrum agent attack.

- Sensors. ($ 27.746 Million)
  - Complete, test, and verify first-generation prototype of live agent biochip sensor.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, R-1 #15

- Complete development of air sampling technology for airborne biological material.
- Continue development of effective and rapid chip-reading capability with enhanced sensitivity.
- Continue the development of unique signatures for bio-agents in mass spectrometry identification.
- Develop biosensor technology for next-generation (bioengineered) threat agents.
- Develop methods for identifying bioregulator-based BW agents.
- Explore options (e.g., training, genetic engineering, etc.) for the use of invertebrates in the detection of BW agents and associated chemicals.
- Construct cell and tissue engineered configurations to enhance optical or electrical signal output from the sensor.
- Investigate optimal system designs for deployment of a single cell and tissue based biosensor, which incorporate environmental sampling, microfluidics, and automated detection.
- Evaluate cell and tissue based informatics from temporal and spatial signals in cell and tissue-based sensors.
- Explore shelf-stabilization strategies for cells and tissues.
- Develop bio-agent sensors and other technologies for use in building protection (fate and transport).
- Develop the capability to predict flow of airborne bio-agents in and around buildings.
- Develop neutralization and decontamination techniques appropriate to buildings.

- Genetic Sequencing of Biological Warfare Agents. ($ 4.000 Million)
  - Develop inventory of DoD-relevant BW agent pathogens requiring sequencing.
  - Determine best methods for rapidly sequencing biological warfare pathogens and related species and strains.
  - Begin development of database mining techniques to find new targets for sensors, diagnostics, and therapeutics.

- Consequence Management. ($ 10.000 Million)
  - Develop distributed BW consequence management smart checklists for automatic pull and push of required information.
  - Continue development of Enhanced Consequence Management Planning and Support System (ENCOMPASS) software toolkit.
  - Demonstrate use of ENCOMPASS for OCONUS air base force protection against a BW attack.
  - Demonstrate use of playbooks and automated checklists for training BW incident responders.
  - Integrate Consequence Assessment Tool Set (CATS) with Electronic Watchboard using the ENCOMPASS architecture.

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- Asymmetrical Protocols for Biological Warfare Defense. ($ 3.500 Million)
  - Initiate an effort in support of biological warfare defense against asymmetrical threats.

- Aerogel. ($ 3.000 Million)
  - Investigate and test capture efficiency as a function of aerogel porosity and composition.
  - Develop aerogel coatings with greater flexibility and adherence to mass spectrometer tape.

(U) **FY 2001 Plans:**

- Anti-Virals/Immunizations. ($ 21.300 Million)
  - Test and validate (in-vivo) a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in edible transgenic plant products.
  - Test and validate (in-vivo) the protective efficacy of vaccines and antibodies produced by plant cells against pathogens.
  - Demonstrate efficacy of the rapid and efficient delivery of pathogen antigens via new genetic vaccine vectors.
  - Demonstrate (in-vivo) the rapid design and development of new vaccines (or therapeutics) against unidentified or unknown pathogens.
  - Demonstrate broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.

- Anti-Bacterials/Anti-Toxins. ($ 21.658 Million)
  - Demonstrate surface expression of specific enzyme molecules for the rapid inactivation of various pathogens.
  - Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial pathogen antagonist.
  - Validate (in-vivo) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Demonstrate (in-vivo) efficacy of broad spectrum, superantigenic, antitoxin antagonists and vaccines.

- Multi-Purpose. ($ 22.200 Million)
  - Develop therapeutic strategies against bioregulators and other mid-spectrum agents.
  - Demonstrate synthetic polymer complements for pathogenic antigens and virulence factors.
  - Develop therapeutic strategies for minimizing harmful immune responses to biological warfare agents.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, R-1 #15

- Demonstrate (in-vitro) the efficacy of monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
- Validate polyvalent inhibitors for blocking pathogens on the surface of target cells in-vivo.
- Identify superantigens for broad protection against biological warfare agents with minimal side effects.
- Validate (in-vivo) the efficacy of subcellular pathogen response imaging for rapid detection.
- Validate technologies broadly applicable to enhance cellular therapeutics (delivery platforms) and virulence modulation (intracellular and inflammatory cascades).

- External Protection. ($ 21.000 Million)
  - Develop a novel architectural approach for the manufacture of materials that are effective in blocking pathogens and limiting disease.
  - Demonstrate a non-aqueous advanced decontamination method.
  - Demonstrate a water purification system effective against a range of biological agents (including toxins and bioregulators).
  - Test initial performance of advanced sorbent materials for the purification of air contaminated with CW and BW agent simulants for individual protection.
  - Build and test a prototype air purification system for collective protection for a group of soldiers.
  - Begin testing of prototype protective system against non-virulent biological warfare agents, bio-toxins, and regulators.

- Advanced Diagnostics. ($ 19.350 Million)
  - Test probe panels in relevant sample types including strategies for rapidly generating new/novel probes.
  - Demonstrate that sample collection and/or preparation techniques do not introduce artifacts.
  - Test, in model systems, one or more of the most promising candidate strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
  - Develop the capability to diagnose exposure to bio-regulator and mid-spectrum agents.
  - Demonstrate, in the laboratory, the feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Evaluate the feasibility of additional strategies (e.g., exhaled breath) for direct identification or detection of infection without direct sample collection.
  - Evaluate instrument designs to perform accelerated patient diagnosis using a rapid single molecule DNA sequencing technique in a model system.

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- Sensors. ($ 24.056 Million)
  - Develop effective and rapid chip-reading capability with enhanced sensitivity and low false alarm rate.
  - Develop advanced alternative technologies for live vs. dead bio-agent identification using peptides and other molecules.
  - Evaluate methods for removing micro-encapsulation of disguised pathogens and/or sensing through the micro-encapsulation.
  - Develop technologies required for next-generation miniature biological detectors including the use of microelectromechanical systems (MEMS), microfluidics, and mesoscopic-sized components.
  - Evaluate false positive and false negative rates for systems of detectors using biomolecular cells or tissues.
  - Exploit and/or mimic the olfactory sensors of biological systems for use in the detection of biological warfare agents.
  - Demonstrate enhanced signal output from engineered cells and tissue based sensors and integrate information from these sensors with user interfaces for predictive responses.
  - Engineer a deployable prototype cell and tissue sensor for field-testing.
  - Develop biosensor models and robust characterization protocols.
  - Investigate standoff techniques for trigger and identification.
  - Develop concepts for sensors capable of detecting biological warfare agent production in underground facilities.
  - Investigate critical design parameters for advanced biologically based biological warfare sensor.
  - Demonstrate use of organisms to collect chemical and biological warfare agents in the field.

- Bio/Chem Defensive Systems. ($ 10.000 Million)
  - Continue fate and transport model development in and around buildings and begin experimental evaluation.
  - Continue to develop decontamination techniques appropriate for structures.
  - Evaluate novel low-pressure-drop, broadband filter technologies.
  - Develop neutralization technologies for aerosolized agents.
  - Conduct integrated system design and begin experimental evaluation.

- Genetic Sequencing of Biological Warfare Agents. ($ 12.500 Million)
  - Continue the genomic sequencing of high-threat known and potential biowarfare agents.

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- Continue development of database mining techniques and test on a subset of pathogenic genomes.

- Consequence Management. ($ 10.000 Million)
  - Demonstrate rapid construction and distribution of specific BW smart checklists for multiple responders.
  - Demonstrate Enhanced Consequence Management Planning and Support System (ENCOMPASS) management of multi-site BW incidents.
  - Demonstrate automatic construction of incident- and responder-specific playbooks and electronic watchboards.
  - Demonstrate use of ENCOMPASS for CONUS air base force protection against BW attacks.
  - Transition ENCOMPASS to National Guard Rapid Assessment and Initial Detection Units and to Air Force Theater Battle Management Core.

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	84.754	145.850	151.000
Current Budget	84.009	131.705	162.064

(U) **Change Summary Explanation:**

FY 1999	Decrease reflects SBIR reprogramming and minor program repricing.
FY 2000	Decrease reflects the net effect of congressional program reductions; congressional adds for aerogel material and asymmetrical protocols; government-wide rescission, and minor program adjustments.
FY 2001	Increase reflects Departmental direction to continue the demonstration of complete genomic sequencing of high-threat known and potential biowarfare agents and expansion of on-going efforts under external protection and medical countermeasures.

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(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 Tactical Technology PE 0602702E, R-1 #17				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	158.953	142.501	121.051	126.679	151.114	161.642	174.306	Continuing	Continuing
Naval Warfare Technology TT-03	19.170	14.582	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Advanced Land Systems Technology TT-04	33.347	27.641	21.972	23.319	43.348	39.162	35.144	Continuing	Continuing
Advanced Targeting Technology TT-05	0.000	0.000	0.000	6.400	5.700	14.700	26.200	Continuing	Continuing
Advanced Tactical Technology TT-06	45.918	34.558	32.232	43.028	45.673	41.530	41.371	Continuing	Continuing
Aeronautics Technology TT-07	30.163	40.748	29.131	20.475	32.593	42.450	47.291	Continuing	Continuing
Advanced Logistics Technology TT-10	20.106	15.296	27.791	23.564	23.800	23.800	24.300	Continuing	Continuing
Joint Logistics ACTDs TT-11	10.249	9.676	9.925	9.893	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Advanced Targeting, Aeronautics, and Logistics technologies.

(U) The Naval Warfare Technology project is focusing on enabling technologies for a broad range of naval requirements. Programs include High Energy Density Materials and Submarine Payloads and Sensors. The High Energy Density Materials program is exploring high risk/high

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pay-off breakthroughs in missile propellants and explosives technologies. The Submarine Payloads and Sensors effort will explore submersible platforms designed to maximize payload capacity.

(U) The Advanced Land Systems Technology project is developing technologies for contingency missions, mine clearing, and anti-personnel landmine alternatives to make U.S. combat forces more deployable, effective, survivable, and affordable. The SLID program has developed and is testing a system for providing protection against missiles and projectiles with explosive warheads. The Advanced Fire Support Systems program will provide rapid response and lethality associated with gun and missile artillery, thereby increasing survivability, yet requiring fewer personnel and less logistical support. The Counter-artillery Force Protection program will explore advanced sensors, munitions and deployment concepts to counter evolving threats. The Dog's Nose/Unexploded Ordnance Detection program will develop sensors for the chemically specific detection of explosives or other chemicals, comparable to the effectiveness of canine olfaction detection. The Alternatives to Antipersonnel Landmines program will explore technologies to obviate the need for mines. The Close-In Sensing program will emphasize new approaches to detect traditionally low signal-to-signal noise or concealed targets. The Active Ballistic Imaging effort will exploit newly discovered phenomenon to facilitate surveillance and targeting in adverse weather conditions.

(U) The Advanced Tactical Technology project is exploring the application of compact lasers; high performance computational algorithms to enhance performance of radars, sensors, communications, and electronic warfare and target recognition and tracking systems; precision optics components for critical DoD applications; miniature air-launched decoy systems; affordable rapid response missile demonstrations; new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, enabling technologies for advanced space systems; and emerging payload delivery concepts.

(U) The Aeronautics Technology project will develop and demonstrate a new family of Micro-Air Vehicles (MAVs). The MAVs will be an order of magnitude smaller than any operational UAV and will be useful in a wide variety of military missions from covert imaging and chemical/biological agent detection to communication enhancement. This project also funds the Micro Adaptive Flow Control (MAFC) program, Small-Scale Propulsion System (SSPS) concepts, the Advanced Rotorcraft Technology (ART) program, the Vertical Take-off and Landing Unmanned Air Vehicle (VTOL UAV) program, and a one-year effort to explore Supersonic Aircraft Noise Mitigation (SS A/C NM).

(U) The Advanced Logistics project is investigating and demonstrating technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment materiel to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently. The project will also develop and

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demonstrate advanced military-grade measures for security, robustness, and scalability to enable the wide-scale application of large-scale agent technology to U.S. military logistics and command and control domains operating in high-tempo conventional and information warfare environments.

(U) The Joint Logistics project is composed of two Advanced Concept Technology Demonstrations (ACTDs) that will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Service logistics communities. The Joint Logistics ACTD will develop JDST capabilities in the areas of force capability assessments, logistic support concept generation and evaluation, distribution, materiel management; maintenance analysis and visualization. The Joint Theater Logistics ACTD will integrate and expand those capabilities to provide realtime in-theater management and analysis tools. Focus areas for the Joint Logistics project correspond to Commander-In-Chief (CINC) and Service requirements to develop JDSTs.

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	169.759	137.626	123.937
Current Budget	158.953	142.501	121.051

(U) Change Summary Explanation:

FY 1999	Decrease reflects SBIR reprogramming; transfer of Simulation Based Design Program to the Defense Logistics Agency; and Section 8058 rescission.
FY 2000	Increase reflects net effect of congressional program reductions; congressional adds for CEROS and Supersonic Aircraft Noise Mitigation; the government-wide rescission; and minor program adjustments.
FY 2001	Decrease reflects net effect of: transition of the Micro Air Vehicles program (Project TT-07); cancellation of the Simulated Battlefield Imagery program (Project TT-04); completion of the Naval Warfare Technology Project (TT-03); and increases for the expansion of the Affordable Rapid Response Missile Demonstrator (Project TT-06) and Advanced Logistics efforts (Project TT-10).

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Naval Warfare Technology TT-03	19.170	14.582	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. The principal enabling technologies include investigation into High Energy Density Materials (HEDM) for advanced explosives and propellants and innovative payload and platform concepts for expanding the envelope of operational capabilities for submersible platforms.

(U) The High Energy Density Materials (HEDM) program fosters high-risk/high payoff efforts that could result in major breakthroughs in missile propellant and explosives technologies applicable to a wide variety of tactical and strategic military systems. The HEDM project will investigate the synthesis of new molecules capable of providing orders of magnitude increases in explosive and/or propulsive energy per unit weight. The stability and energy content of several such molecules have been predicted theoretically. The molecules will contain only nitrogen atoms or a very high percentage of nitrogen atoms, a situation that makes their production and use environmentally friendly. The potential benefits include: thermodynamic properties which could result in their having two-to-six times as much propulsive/explosive energy as current state-of-the-art operational materials, the "greening" of production and use, and reduction of detectability. Missile systems with size constraints could have increased range, maneuverability for flexible targeting, and/or increased kill effectiveness due to improvements in both the propellant's thrust and the warhead's lethality (per weight and volume). The program builds on theoretical work previously sponsored by other DoD organizations and provides some high risk excursions into materials which are theoretically possible but for which there is no currently known defined synthetic route.

(U) Current submarine designs are significantly limited in the quantity and types of payloads and sensors that can be accommodated; in turn, these limitations increasingly constrain the view of the future operational utility of the submarine platform. The Submarine Payloads and Sensors Program is intended to explore the possibilities that emerge when a unified set of payload and sensor concepts, operational implications, and supporting platform concepts are formulated in a balanced manner. Flexible platform concepts will be evaluated to support future multiple payload/sensor approaches that include the areas of advanced ordnance, advanced sensors, and adjuvant vehicles. Technology and programmatic roadmaps for the interlocking payload, sensor, combat system and platform concepts that evolve will be defined as part of this effort.

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(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Project Genoa. ($ 6.116 Million)
  - Demonstrated Phase I initial operational capability of the data retrieval and visualization capability, initial operational capability of the crisis modeling capability, and began installation of modeling capability and integration with data retrieval capability at CINCPAC and DIA. Began installation and integration of advanced presentation capability. Transitioned Phase I application effort to PE0603760E, Project CCC-01.

- High Energy Density Materials (HEDM). ($ 1.744 Million)
  - Produced new, stable, all nitrogen Ion N_5^+. One of only 3 stable all nitrogen species (N_2, discovered 1772 and N_5^-, discovered 1890).
  - Obtained spectrographic indications of N_4.
  - Continued development of synthesis pathways and theoretical chemistry support activities for High Energy Density Materials.
  - Investigated methods to scale-up successful synthetic routes to production quantities.

- Submarine Payloads and Sensors. ($ 4.366 Million)
  - Commenced concept development phase to define innovative concepts in advanced ordnance, advanced sensors, and adjuvant vehicles applicable to submarine platforms.
  - Created two initial payload concepts together with associated mission concepts. Commenced initial concept refinement and initiated utility assessments. Continued development of additional concepts.

- Center of Excellence for Research in Ocean Sciences (CEROS). ($ 6.944 Million)
  - Continued most promising ocean science efforts at the CEROS.

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(U) FY 2000 Plans:

- High Energy Density Materials (HEDM). ($ 4.678 Million)
  - Scale up synthesis of High Energy Density Materials (HEDM) to gram quantities and experimentally verify physical properties.
  - Attempt synthesis of novel nitrogen molecules ($N_5^+ N_3$).

- Submarine Payloads and Sensors. ($ 2.904 Million)
  - Complete concept development phase, refining and finalizing multiple payload and sensor concepts and associated mission concepts.
  - Define and mature two flexible platform concepts capable of supporting multiple payload and sensor concepts.
  - Identify development roadmaps and technology risks and opportunities associated with the final system and platform concepts.

- CEROS. ($ 7.000 Million)
  - Select projects for funding, either new efforts or follow-on development to projects selected in previous years.
  - Contract selected projects and monitor progress of ocean related technologies of high interest to the DoD and the State of Hawaii.
  - Effect the transition of appropriate products to military and civilian use.

(U) FY 2001 Plans:

- Not Applicable.

(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 Tactical Technology PE 0602702E, Project TT-04					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Land Systems Technology TT-04	33.347	27.641	21.972	23.319	43.348	39.162	35.144	Continuing	Continuing

(U) Mission Description:

(U) This project is developing technologies for enhancing the US military effectiveness and survivability in operations ranging from force-on-force conflict to military Operations-Other-Than-War (OOTW). This emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of US or allied forces to enemy fire. This project consists of the following main efforts: Small Low-cost Interceptor Device (SLID); Advanced Fire Support Systems (AFSS); Counter-artillery Force Protection (CFP); Dog's Nose/Unexploded Ordnance Detection; Alternatives to Antipersonnel Landmines; Close-In Sensing; and Active Ballistic Imaging.

(U) The SLID program is developing and testing a system that protects threatened systems against missiles and projectiles with explosive warheads. The SLID system will detect, track and intercept threats such as anti-armor missiles, mortars, artillery, and top-attack sensor fused munitions at a standoff distance sufficient to render them ineffective. Applications for the SLID system include: self-defense of vehicles; defense of high value fixed sites such as command centers, hospitals, embassies, parked aircraft and radars; and, with further development, self defense of naval platforms and low-speed aircraft. A completing program, FY 1999 was the final year of DARPA funding for SLID.

(U) The Advanced Fire Support Systems (AFSS) program will develop and test a containerized, platform-independent multi-mission weapon concept. These systems will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support, and lower life-cycle costs, while increasing survivability compared to current gun and missile artillery. AFSS will allow the military to capitalize on recent advances in military doctrine and infrastructure, such as the ongoing digitization of the Army. The program will develop and demonstrate highly flexible systems including a modular, multimission precision missile, a remotely commanded self-locating launcher, and a command and control system compatible with military doctrine. Beginning in FY 2001, the Advanced Fire Support System will be a key element supporting beyond-line-of-sight engagements for Future Combat Systems and is funded in PE 0603764E, Project LNW-03, Future Combat Systems.

(U) The Counter-artillery Force Protection (CFP) program will develop concepts for defending forces and civilian enclaves against air threats including high rate of fire missile artillery carrying submunitions. The program will explore advanced sensors, munitions and deployment concepts to counter this evolving threat, and will include both active defense and counterforce options.

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(U) The Dog's Nose/Unexploded Ordnance (UXO) Detection program will develop sensors for the chemically specific detection of explosives or other chemicals characteristic of land mines and/or shallowly buried UXOs. The sensors developed under this program will provide soldiers with the effectiveness of canine olfaction detection without the logistics and other constraints imposed by the use of live animals. These chemically specific sensors will work either singly or in conjunction with other technologies such as the hyperspectral mine detector, developed under the Small Unit Operations (SUO) program in PE0603764E, project LNW-02 that exploit different physical features.

(U) DARPA is developing technologies that provide alternatives to antipersonnel landmines (APLs) under this project. The systems developed will provide our warfighter with enhanced capabilities that obviate the need for APL. Technologies include self-healing antitank (AT) minefields (that allow the protection of AT mines without the use of APLs) and tags with minimally guided munitions that allow the compression of critical timelines and distance constraints imposed by conventional indirect and direct fire approaches.

(U) The Close-in Sensing program will develop technologies to complement our national remote sensing assets (space and airborne). The close-in sensors will exploit various phenomenologies to make robust detection, classification, and identification of mobile time-critical targets and characterization of the local radio frequency (RF) environment. The technologies developed will emphasize new approaches to detect traditionally low signal-to-noise or concealed targets.

(U) The Active Ballistic Imaging program will explore a newly discovered phenomenon that allows "seeing" through smoke, fog, and rain. This effort will conduct experiments to understand the phenomenon and develop the ultra short pulse laser technology, holographic beam control, and the fast gated imaging sensor technology.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Small Low-cost Interceptor Device (SLID). ($ 5.322 Million)
  - Completed testing of interceptor system.

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- Completed testing of fire control system.
- Transitioned ground vehicle active protection technology to Army.

- Unexploded Ordnance Detection. ($ 20.020 Million)
  - Conducted field demonstrations of a prototype chemically specific land mine detector paired with other sensors.
  - Investigated plume-tracing strategies in support of future search strategies.
  - Characterized chemical signatures of land mines in a variety of environments.
  - Conducted a series of blind tests to establish current sensor capabilities.
  - Conducted a prototype field demonstration in the Balkans.

- Advanced Fire Support System (AFSS). ($ 8.005 Million)
  - Continued feasibility analysis of advanced technologies for integration into platform/missile system components.
  - Developed detailed designs for the Advanced Fire Support System architecture.
  - Conducted evaluations and testing of high risk and critical components.
  - Defined system demonstration objectives.

(U) **FY 2000 Plans:**

- Advanced Fire Support System (AFSS). ($ 13.119 Million) [Future Combat Systems – related = $13.119 Million]
  - Complete detailed design for AFSS objective demonstration system, including launch, fire control, and each of the demonstration flight systems.
  - Develop and test component hardware and software for AFSS.
  - Continue advanced concept feasibility assessments.
  - Initiate hardware-in-the-loop tests.
  - Plan and initiate limited objective flight tests.

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- Counter-artillery Force Protection (CFP). ($ 1.094 Million)
  - In conjunction with the Army, define one or more system architectures, including sensors, munitions and deployment to meet the mission needs for enclave protection against missile artillery.

- Unexploded Ordnance Detection. ($ 6.457 Million)
  - Continue the development of chemical sniffers for land mine detection.
  - Reduce size, improve field response to interferents, and improve sampling system.
  - Demonstrate a condensed phase detector in the field in multiple configurations (handheld and vehicle mounted) and formalize transition with the user.

- Alternatives to Antipersonnel Landmines. ($ 6.971 Million)
  - Begin preliminary development of antitank minefield healing algorithms.
  - Conduct initial demonstration of self-healing antitank mine subsystems – individual mine-surrogate mobility concepts and mine-to-mine communication methods.
  - Develop and demonstrate tagging concept(s) in the laboratory.

(U) **FY 2001 Plans:**

- Alternatives to Antipersonnel Landmines. ($ 9.925 Million)
  - Conduct field demonstration of self-healing antitank minefield using surrogate mines.
  - Demonstrate adhesion of tags in the field.
  - Demonstration of in-field wakeup and down-range communication with tags.

- Close-in Sensing. ($ 9.547 Million)
  - Investigate potentially promising radio frequency phenomenology collection techniques.
  - Develop novel tagging technologies.
  - Assess data exfiltration schemes.

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- Active Ballistic Imaging. ($ 2.500 Million)
  - Conduct phenomenology experiment.
  - Perform preliminary system performance modeling and assessment.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Tactical Technology TT-06	45.918	34.558	32.232	43.028	45.673	41.530	41.371	Continuing	Continuing

(U) Mission Description:

(U) This project focuses on five broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, and high-power laser applications; (b) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (c) precision optics components for critical DoD applications; (d) aerospace electronic warfare systems (e.g. coherent spoofers, decoys, jammers); and (e) very high speed aerospace vehicle and enabling technology (Affordable Rapid Response Missile Demonstrator). Additionally, this project will develop new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, enabling technologies for advanced space systems, and emerging payload delivery concepts.

(U) Compact Lasers: This program will develop compact diode-pumped, solid-state lasers and laser-diode arrays (10x improvement in efficiency) with tens of watts average power output and wavelength tuneability in the mid-infrared spectral regions to provide laser sources for infrared countermeasures against heat-seeking missiles for rotary wing/fixed wing aircraft and sea-borne platforms. Additionally, it will develop ultra broadband and very short pulse solid state laser technology and ultra high power short pulse lasers. The program will explore a combination of microelectromechanical systems (MEMS) based electro-optic spatial light modulators in combination with very short pulse solid state lasers to provide powerful new capabilities for secure communication up-links (multi-gigabits per second), aberration free 3-dimensional imaging and targeting at very long ranges (> 1000 kilometers). Lastly, innovative design concepts and system integration of MEMS based spatial light modulators (SLMs), which provide a quantum leap in wavefront control, photonics and high speed electronics, will be explored for an affordable and high value communications, image sensing and targeting system for use well into the 21st century.

(U) High Performance Algorithm Development and Advanced Mathematics for Microstructural Process Control: these programs will identify, develop, and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a wide variety of DoD systems applications. They will look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit the power of large-scale computational resources as they apply to specific problems of interest. The products are typically advanced algorithms and design methodologies. DARPA is pursuing the development of well-conditioned fast algorithms and strategies for the exploitation of high-

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dimensional data (i.e., data with a high number of degrees of freedom) in order to deal with a variety of complex military problems such as adaptive array processing for missile seekers, waveform design for spaceborne sensors and communication applications, virtual integrated prototyping of advanced material processing, efficient high fidelity scattering computations for radar cross sections, and efficient mapping of signal processing kernels onto advanced DoD hardware architectures.

(U) Precision Optics: The Precision Optics program will develop mathematical design tools and fabrication strategies for conformal sensor windows, cylinders, toroids, and diffractive optical elements. These tools and strategies, once developed, will provide distortion-free imaging with greater than hemispherical field-of-regard and reduced aerodynamic drag for precision strike and integrated bomb damage assessment for next-generation airborne platforms/high-speed missiles.

(U) Aerospace Electronic Warfare Systems: The Miniature Air-Launched Decoy (MALD) advanced concept technology development (ACTD) program will develop and demonstrate a small, inexpensive air-launched decoy system for Suppression of Enemy Air Defenses (SEAD). MALD will be employed to enhance the survivability of friendly aircraft by establishing air superiority through stimulating, diluting and confusing enemy Integrated Air Defense Systems (IADS). The jointly funded Air Force, OSD/AT&L, and the DARPA program's major focus is affordability. DARPA, together with the Air Force Air Combat Command only has one requirement for the program: An Average Unit Flyaway Price (AUFP) of $30,000 per decoy for a 3,000 unit buy. The design will leverage the Small Engine Application Program SENGAP engine program, miniaturization of electronics, and commercial equipment and process to achieve design goals. Other applications of the miniature air vehicle system to employ other electronic warfare approaches, which include coherent radio frequency (RF) spoofers, and RF jammers.

(U) The Affordable Rapid Response Missile Demonstrator (ARRMD): The ARRMD will destroy high value targets in heavily protected areas at long standoff ranges, quickly and affordably. Generally, the ARRMD program is pursuing a highspeed air breathing propulsion system that will more than triple the installed specific impulse (ISP) of current rocket power systems. The ARRMD program will prove technologies that could enhance future large scale, high speed payload delivery systems and access to space systems.

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(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Compact Lasers. ($ 4.200 Million)
  - Demonstrated and delivered a brassboard high powered mid-infrared laser for ship based closed loop infrared countermeasures.
  - Demonstrated quantum cascade laser diode arrays operating at mid-infrared wavelengths.

- High Performance Algorithm Development. ($ 11.800 Million)
  - Validated prototype electromagnetic scattering models for objects in ground clutter.
  - Demonstrated data, sensor, and algorithm fusion algorithms for signal and image processing applications that exploit the feature extraction capability of wavelets.
  - Demonstrated fast algorithms for electromagnetic scattering at subwavelength scales and off rough surfaces.
  - Demonstrated feasibility of mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in complex physical process simulations.

- Advanced Mathematics for Microstructural Process Control. ($ 7.869 Million)
  - Developed algorithms for fundamental chemical calculations that allow treatment of larger systems and more extended phenomena in thin film deposition.
  - Developed multiresolution homogenization techniques to reduce systems of partial differential equations to equations amenable to process optimization and design of control algorithms.
  - Validated island dynamics mathematical model and level set methods for epitaxial growth.

- Precision Optics Technology. ($ 3.750 Million)
  - Demonstrated replicated conformal missile domes.
  - Demonstrated designs for conformal missile domes.
  - Demonstrated assembly of conformal missile domes for laboratory characterization.

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- Miniature Air-Launched Decoy (MALD). ($ 11.107 Million)
  - Continued operational demonstrations; acquired limited flight clearance (Seek Eagle); fabricated thirty-two operational test assets and transitioned to Services.
  - Completed feasibility study to validate that a low cost interceptor derivative can be developed from a MALD. Established preliminary and final design after cost and performance trades. Determined seeker design options and turbine engine integration.
  - Continued to explore other concepts for low cost MALD airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 5.892 Million)
  - Completed propulsion integrated flowpath and manufacturability demonstrations.
  - Conducted vehicle force and moment testing.
  - Conducted Warfighting Analysis Lab exercises.
  - Started system preliminary design.
  - Continued exploration of supporting technologies for hypersonic missiles.
  - Refined unit cost estimate.
  - Down-selected to single concept (Waverider).

- Rapid Domination. ($ 0.500 Million)
  - Conducted exploratory study to examine the concept of rapid dominance.
  - Analyzed the impact of a very rapid and punitive military response to an adversary's aggression.

- Advanced Tactical Technology Concepts. ($ .800 Million)
  - Continued feasibility evaluation studies of emerging advanced tactical technology concepts, including high-speed launch of small payloads, autonomous maintenance capabilities, and beyond next generation space-based sensors.

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(U) **FY 2000 Plans:**

- Compact Laser. ($ 5.577 Million)
  - Develop system applications concept and preliminary design of spatial light modulators and integrated electronics for Coherent Communications, Imaging and Targeting (CCIT).
  - Perform feasibility studies and concept development of enabling alignment and docking technologies using compact solid state laser technology for advanced space-based systems.

- Precision Optics. ($ 7.160 Million)
  - Complete assembly and test of conformal optics Stinger missile dome to quantify performance improvements.
  - Demonstrate imagery through Stinger conformal missile dome.

- High Performance Algorithm Development. ($ 8.487 Million)
  - Demonstrate utility of multiscale segmentation and registration algorithms in DoD automatic target recognition applications.
  - Develop advanced mathematical algorithms for high throughput hyperspectral infrared imaging.
  - Validate fast algorithms for electromagnetic scattering at subwavelength scales and off of rough surfaces.
  - Develop codes for predicting antenna radiation patterns and scattering off of electrically large, smooth impenetrable bodies.

- Advanced Mathematics for Microstructural Process Control. ($ 2.936 Million)
  - Construct and test control/optimization codes for sputtering, evaporation and molecular beam epitaxy reactors.
  - Extend level set methodology to complex diffusion processes in thin film processing.

- Miniature Air-Launched Decoy (MALD). ($ 1.940 Million)
  - Continue operational assessment exercises with thirty-two test assets to support transition to Air Force.
  - Continue to investigate ACTD design shortfalls and testing anomalies. Support redesign efforts to increase reliability.

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- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 7.958 Million)
  - Conduct booster configuration trade study.
  - Conduct second force and moment test series.
  - Perform design optimization studies.
  - Select demo booster configuration.
  - Conduct structural validation testing.
  - Complete system preliminary design.
  - Continue exploration of supporting technologies for hypersonic missiles.
  - Initiate Phase II activities.
  - Initiate detailed vehicle design.
  - Complete flight test plan for first flight articles.

- Advanced Tactical Technology Concepts. ($ .500 Million)
  - Explore and assess feasibility of new concepts for high-speed launch of small payloads and autonomous maintenance capabilities, exploiting next generation space-based sensors (e.g. lasers, electro optic, and millimeter wave).

(U) **FY 2001 Plans:**

- Compact Lasers for Coherent Communications, Imaging and Targeting. ($ 1.985 Million)
  - Develop breadboard system with high-speed electronics integration.
  - Demonstrate greater than 1-kilometer operation for static platform and target.
  - Develop very high power short pulse lasers using plasma based pulse compression.

- High Performance Algorithm Development. ($ 9.000 Million)
  - Demonstrate feasibility and portability of optimized portable application library generation approaches for a complete signal-processing algorithm.
  - Develop and test algorithms for variable precision filters for adaptive signal processing.
  - Develop tool set implementing algorithmic, memory, and compilation models applied to a multipole test problem.

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- Develop algorithms for predicting and optimizing antenna radiation patterns and scattering, both off of and through inhomogeneous materials and deep cavities.
- Develop computationally efficient geometric compression and registration algorithms for topography/imagery databases.

- Advanced Mathematics for Microstructural Process Control. ($ 1.918 Million)
  - Validate reduced order model and algorithms for sensing and control of thin film vapor deposition processes.
  - Demonstrate advanced molecular dynamics/accelerated molecular dynamics simulation techniques for the growth of multilayer materials.

- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 17.866 Million)
  - Conduct high mach number wind tunnel testing.
  - Conduct critical design review.
  - Initiate fabrication of missile demonstrators.
  - Continue exploration of supporting technologies for hypersonic missiles.
  - Initiate flight weight engine ground demonstrator test hardware fabrication.
  - Develop hybrid rocket as a low cost booster.

- Advanced Tactical Technology Concepts. ($ 1.463 Million)
  - Perform feasibility evaluation studies of emerging advanced tactical technology concepts, including enhanced air vehicle survivability, innovative engines and propulsion techniques, payload delivery methods, and enabling technologies for advanced space systems.

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(U) Other Program Funding Summary Cost: *(In Millions)*

	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	Cost to Complete	Total Cost
MiniatureAir-Launched Decoy (MALD)	1.000	.500	0.000	0.000	0.000	0.000	0.000	N/A

PE 0603750D, Advanced Concept Technology Demonstrations

(U) Schedule Profile:

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aeronautics Technology TT-07	30.163	40.748	29.131	20.475	32.593	42.450	47.291	Continuing	Continuing

(U) Mission Description:

(U) Aeronautics Technology efforts will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements.

(U) A new family of Micro-Air Vehicles (MAVs) that are at least an order of magnitude smaller than current flying systems (less than 15 cm in any dimension) will be developed and demonstrated. The capability to accomplish unique military missions as diverse as small unit reconnaissance and surveillance, support of military operations in urban terrain, targeting and tagging high-value targets in denied areas, and, biological-chemical agent detection and characterization, will be stressed through an examination of a variety of vehicle concepts. The resulting capability should be especially beneficial in the emerging urban warfighting environment, characterized by its complex topologies, confined spaces and areas (often internal to buildings), and high civilian concentrations. The MAV program will focus on the technologies and components required to enable flight at these small scales, including flight control, power and propulsion, navigation and communications. These will build upon and exploit numerous DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectromechanical Systems (MEMS), advanced sensors, lightweight, efficient high density power sources, and advanced electronic packaging technologies.

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large-scale aerodynamic flows using small-scale actuators. MAFC technologies combine adaptive control strategies, distributed sensor arrays, and advanced actuator concepts like micro-scale synthetic jets, MEMS-based microactuators, pulsed-blowing and smart structures to delay or prevent fluid flow separation. MAFC technologies will be explored for a wide range of applications such as adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, lightweight gas turbine engines, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision. Advanced flow control concepts will be explored in the context of system level performance benefits and cost assessments. MAFC technology evaluations will be made under system-relevant flow conditions, and the most promising approaches will be selected for component- or system-level demonstration.

(U) The goals of the Advanced Rotorcraft Technology (ART) program are to investigate the merits of various advanced rotorcraft technologies and to conduct technology maturation efforts for two such technologies: face gear, split torque transmissions, and variable diameter tilt

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rotors. The current ART program consists of the following tasks: Task 1 will complete design and fabrication, and perform tests of a full scale split torque helicopter main rotor transmission based on face gear technology; a unique gear grinding process that enables production grinding of aircraft quality face gears. The project will yield a completed 2,828 horsepower demonstrator transmission, and will perform testing of the design's concentric face gear split torque concept, durability improving modifications to gears and smaller subsystem tests. Steps required to do this include furthering the face gear manufacturing technology developed to-date to enable precision-grinding of the large demonstrator transmission face gears, instrumenting of the test gears, assembly of the gearbox, and performing tooth backlash and pattern development, slow roll tests, split torque concept tests and durability tests. These tests will determine tooth strength and torque split percentages for the design concept. Task 2 will consist of tests and experiments to investigate and mature Variable Diameter Tilt Rotor (VDTR) technology. The tilt rotor concept, as embodied in the V-22 aircraft, and as previously demonstrated in the XV-1 and XV-15 prototype aircraft, attempts to achieve the speed of a turboprop aircraft combined with the vertical takeoff and landing capability of a helicopter. This is accomplished through a mechanism that translates the vertical, lifting plane of a helicopter to the horizontal, thrusting plane of a propeller. The size of the rotor/propeller in the aforementioned applications is compromised between that desired for a lifting rotor (large diameter) and that size desired for a thrusting propeller (small diameter). The VDTR concept is an attempt to optimize both the rotor size and the propeller size by including a mechanism that extends and retracts the diameter of the rotating airfoils. While such a design is theoretically feasible and has been demonstrated in small-scale wind tunnel experiments, the concept involves considerable mechanical complexity and aerodynamic challenge. Task 3 is a research project to create a knowledge base and computer code to analyze the operational merit of advanced rotorcraft technologies such as Variable Diameter Tilt Rotor (VDTR), Face Gears, Microadaptive-Flow Control, and Smart Materials. This study will also address the relative merits of such technologies when applied in short takeoff, vertical landing (STOVL) aircraft as contrasted with vertical takeoff, vertical landing (VTOL) aircraft.

(U) Concepts for a new, small-scale class of propulsion systems will be developed in the size range from 0.5 cm to 5.0 cm in diameter, with thrust levels from 10 g to 10.0 kg. They will enable future development of a new generation of very small weapons and military platforms including micro air vehicles, unmanned combat air vehicles, missiles and space launch vehicles. Radical new capabilities to be explored range from shirt-button-sized micro gas turbine and micro rocket engines to 5-cm scale gas turbine and pulse detonation engines. Technologies, which may enable these systems, may be explored at larger scale to prove feasibility. Examples of new mission capabilities may include delivery of very small (200g) satellites to low earth orbit, light weight, long endurance miniature reconnaissance vehicles, and extended range small scale precision munitions. These small-scale munitions would complement emerging unmanned vehicle systems and greatly increase mission capabilities by simultaneously increasing loadout, range and precision.

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(U) DARPA, in partnership with the Office of Naval Research and industry, formulated a program to explore two innovative new vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first concept, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. The second concept (A160) exploits a hingeless, rigid, rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. The VTOL UAV program transitioned to PE 0603285E in FY 2000.

(U) The Supersonic Aircraft Noise Mitigation program is directed towards the development of a vehicle capable of long range missions with sustained supersonic flight with low takeoff noise and mitigated sonic boom. Highly integrated vehicle concepts will be explored to simultaneously meet the cruise range and noise level goals. Advanced airframe technologies will be explored to minimize sonic boom and vehicle drag. High performance propulsion systems will be developed to permit long-range supersonic flight with low takeoff and cruise noise levels.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Micro Air Vehicle (MAV). ($ 12.213 Million)
  - Conducted MAV system development and fabrication. Continued exploration and demonstration of flight enabling technologies and subsystems. Initiated flight test planning for propelled rotary-wing and fixed-wing reconnaissance vehicle systems incorporating operational templates, design flight capabilities, and mission characteristics. Initiated advanced MAV concept definition.
  - Conducted assessment of small-scale air-breathing and rocket propulsion systems. Systems evaluated included micro-turbojet and micro-rocket engines, pulsed combustor engines, and miniature gas turbine and pulse-detonation engines. Initiated development of Small Scale Propulsion Systems program.

- Micro Adaptive Flow Control (MAFC). ($ 5.381 Million)
  - Completed studies of MAFC feasibility for high work compressors, advanced inlet and maneuvering technologies, and rotary and tilt wing hover vehicles.
  - Initiated development and demonstration of MAFC actuator and controller technologies for system-relevant flow conditions.

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- VTOL Concepts. ($ 12.569 Million)
  - Completed detailed designs, analyses, simulations and component tests.
  - Conducted engineering, endurance and ground tests.
  - Completed wind tunnel and full scale propulsion system/rotor testing of the Canard Rotor/Wing (CRW) concept.
  - Initiated fabrication of two CRW demonstrators and three A160 demonstrators.
  - Conducted initial flight tests of A160 flight control systems on a Robinson R-22 helicopter modified for unmanned flight.

(U) FY 2000 Plans:

- Micro Air Vehicle (MAV). ($ 8.006 Million)
  - Complete development of flight enabling technologies for micro air vehicles.
  - Complete fabrication, flight testing and demonstration of multiple fixed-wing and rotary-wing MAV systems.
  - Complete development of MAV compatible power and propulsion subsystems, autonomous navigation and control subsystems, and sensor subsystems.
  - Continue concept of operations evaluation for military use.

- Micro Adaptive Flow Control (MAFC). ($ 8.695 Million)
  - Explore new approaches to MAFC actuator and controller development.
  - Continue to assess actuator, sensor, and control system performance, control authority, bandwidth and power requirements.
  - Explore integration of MAFC technology into feasibility demonstrations for selected military applications, including high-work compressors and fixed-and rotary wing air vehicles.

- Small Scale Propulsion Systems (SSPS). ($ 4.606 Million)
  - Complete concept evaluation of several small-scale propulsion systems, including turbines, rockets and internal combustion designs.
  - Begin detailed design of selected systems for brassboard testing.

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- Advanced Rotorcraft Technology (ART). ($ 3.179 Million)
  - Conduct design work on the face gear, split torque helicopter transmission, including ice and exposure to sand as well as extreme hot and cold ambient temperature conditions.

- Advanced Aeronautic Concepts. ($ 1.262 Million)
  - Conduct technology assessments and feasibility testing of advanced aeronautic concepts, including supersonic laminar flow, air-to-air resupply and continuous aerodynamic control surfaces.

- Supersonic Aircraft Noise Mitigation (SS A/C NM). ($ 15.000 Million)
  - Develop technologies for long range supersonic aircraft having low sonic boom and noise signature, range augmentation through low vehicle drag, and advanced propulsion systems.
  - Develop highly integrated systems concepts for a supersonic long range aircraft.

(U) **FY 2001 Plans:**

- Micro Air Vehicle (MAV). ($ 0.646 Million)
  - Complete advanced MAV development including system fabrication and all flight-testing; complete military concept of operation evaluation and complete transition of MAV systems to Services.

- Micro Adaptive Flow Control (MAFC). ($ 12.903 Million)
  - Initiate fully controlled MAFC technology development and testing.
  - Initiate studies to integrate MAFC technologies into full-scale engine and aircraft systems.

- Small Scale Propulsion Systems. ($ 9.925 Million)
  - Complete design for propulsion systems.
  - Complete subsystem fabrication.
  - Begin subsystem checkout and brassboard demonstrations.

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- Advanced Rotorcraft Technology (ART). ($ 5.657 Million)
  - Complete design work and begin manufacturing of a face gear helicopter transmission.
  - Complete reliability testing of extension/retraction and locking mechanisms for the variable diameter tilt rotor.

(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 Tactical Technology PE 0602702E, Project TT-10					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Logistics Technology TT-10	20.106	15.296	27.791	23.564	23.800	23.800	24.300	Continuing	Continuing

(U) Mission Description:

(U) The overarching objective of the Advanced Logistics Technology project is to revolutionize the way the DoD plans, executes, monitors, and dynamically replans logistics support across the entire spectrum of operational environments from day-to-day routine peacetime operations, disaster relief, non-combatant evacuation, peacekeeping, peacemaking, and minor and major contingencies. The project consists of two major programs, the Advanced Logistics Program and the UltraLog Program.

(U) The Advanced Logistics Program will investigate and demonstrate technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment material to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently than ever before. Currently, this is accomplished using isolated, independent, and sometimes incompatible systems, processes and data. Therefore, the very rapid replanning and redirection necessary to support missions involving simultaneous local and major regional conflicts cannot be accomplished today. The Advanced Logistics Program will address these shortcomings and enable this significant capability to be developed. In addition, the program has enormous potential for cost savings through greatly improved management of transportation and logistics assets. ALP will develop automated, multi-echelon, collaborative logistical/transportation technologies that will provide warfighters with an unprecedented capability to monitor, rapidly replan, and execute the revised logistics plan as the situation requires, even while assets are enroute to the theater. The Advanced Logistics Program will focus on the following three areas: 1) development of applications providing a technology environment that allows warfighters to rapidly understand and assess the logistics and transportation implications of a crisis situation, to generate effective plans and courses of action, to monitor a plan's execution and to use that information to re-plan; 2) automated systems that will enable significant efficiency improvements in transportation and logistics, such as improving access to data, monitoring the condition and status of shipments, personnel, inventories, logistics assets and the infrastructure, the creation of "plan sentinels" to serve as an early warning system for plan deviations, and improved theater distribution; and 3) development of a computer network infrastructure that allows distributed real-time visualization and interaction with all phases, elements and components of the military and commercial transportation infrastructure. The capabilities from these three areas will be integrated to demonstrate a prototype end-to-end system solution. The use of agent technology remains the best approach to maintaining information superiority of the future battlespace. However, full and effective fielding of this technology also requires revolutionary new approaches and extensive systemic architecture

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analysis and experimentation to create a wartime infrastructure that is known and trusted to be secure, robust and scalable. ALP will also perform a preliminary investigation of the basic military-grade measures for security, scalability and robustness to enable the wide-scale application of large-scale agent technology to U.S. military logistics and command and control domains operating in high-tempo conventional and information warfare environments. A number of areas related to security, scalability and robustness to extend and enhance the ALP architecture will be analyzed. Starting with the ALP baseline, Architecture Red Teams will evaluate the features and deficiencies of each capability or combination of capabilities. The product of this analysis will serve as the roadmap and objectives for the UltraLog program, to begin in FY 2001.

(U) The UltraLog Program will build on the baseline security, robustness and scalability investigation and analysis during the Advanced Logistics Program and develop and demonstrate advanced military grade measures for security, robustness, and scalability to enable the wide-scale application of large-scale agent technology to U.S. military logistics and command and control domains operating in high-tempo conventional and information warfare environments. UltraLog's approach will be to start with the infrastructure developed by the Advanced Logistics Program (ALP). UltraLog will pursue research breakthroughs in four main areas: (1) Security: Investigate information pedigree, white-noise generation, dynamic random routing, agent gateways, dynamic PKI key management, recovery reconstruction protection, dynamic communications and security measures, information rovers, correlation and isolation of compromised agents and other techniques to achieve a secure, trusted system even under directed information warfare attack; (2) Scalability: Investigate assured convergence, automatic dampeners, adaptive configuration, resource pooling/proxy, variable fidelity processes, sliding temporal horizons, ultra-efficient agent negotiations, reactive plan space management and other techniques to achieve a highly scalable and stable system even under very chaotic wartime environments; (3) Robustness: Investigate non-local persistence, fault tolerance and recovery, distributed consistency checking, partial state validation, dynamic communications-aware redundancy, dynamic adaptation, temporal horizons and other techniques to achieve a state of high survivability under frequent and significant failure warfare environments; and (4) Systems Integration and Development: Synergistically combine security, scalability and robustness techniques that will provide the highest level of capability while ensuring the overall functionality of the distributed logistics enterprise is preserved. Though many of the research efforts will be accomplished independently and in parallel, the real challenge will come in the integration synergy of the various techniques to produce the desired systemic effects. Architecture Red Teams will also be used to evaluate the features and deficiencies of each capability or combination of capabilities, annually. These evaluations will drive the following year's focus, expanding where there is promise and curtailing what has proven ineffective. Each year the evaluation environment will become more complex, the requirements greater, and the evaluation space expanded to eventually create the most brutal information warfare environment possible in an experimental environment.

(U) The Advanced Logistics Technology project supports Joint Vision 2010, US Transportation Command, Defense Logistics Agency, and Service initiatives, and is coordinated with other related logistics efforts within the DoD. As these technologies mature, they will immediately

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transition to other joint initiatives which include the Defense Logistics Agency's Logistics Research and Development Demonstration (PE0603712S), the Joint Logistics Advanced Concept Technology Demonstrations (Project TT-11), and eventually to the Global Command and Control System (GCCS) and the Global Combat Support System.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Advanced Logistics Program. ($ 20.106 Million)
  - Demonstrated an integrated environment to support the planning, execution and monitoring of a unit deployment from point of debarkation through in-theater distribution, including automated infrastructure assessment and monitoring.
  - Developed and demonstrated the ability to negotiate the exchange of information between suppliers and buyers, including rapid, flexible item and item relationship catalogs for automated sustainment processing.
  - Developed automated deviation detection and triggering of the replanning processes. Continued development of a dynamic critical items list for sustainment planning and execution. Developed and demonstrated automated medium grained course of action evaluation that is linked to the war plan.

(U) FY 2000 Plans:

- Advanced Logistics Program. ($ 15.296 Million)
  - Develop capability to automatically plan and schedule movements from installation to the theater of operations and integrate the resulting movement plan with operations within the theater. Demonstrate capability for users to visualize multiple facts of the transportation schedule.
  - Develop capability to dynamically manage stockage levels across multiple supply chain levels and, multiple echelons, services and agencies.
  - Develop capability to automatically notify users when projected completion of an executing task differs from planned timeline.

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- Construct and conduct a detailed baseline analytical evaluation of the Advanced Logistics Program architecture for security, scalability and robustness.
- Begin to establish the development and experimental environments, to include necessary security considerations and classifications for large-scale experimentation of agent societies under kinetic and information warfare environments.

(U) FY 2001 Plans:

- Advanced Logistics Program. ($ 9.925 Million)
  - Develop capability to automatically build and compare logistics plans in support of four operational courses of action in four hours.
  - Develop capability to monitor resource information, availability, capacity, costs and to view past, present and projected logistical situations.
  - Conduct a pilot test of advanced logistic technology using the Focused Logistics Wargame 2001.
  - Develop plans for conducting follow-on pilot tests.

- UltraLog. ($ 17.866 Million)
  - Complete establishment of development and experimental environments.
  - Design, develop and evaluate a variety of security, scalability and robustness technologies that demonstrate the potential for solving various aspects of the UltraLog problem space, with special attention to proving the feasibility of each technique and determining the probability of success based on the technical and functional requirements of each approach.
  - Perform systemic analysis of combinations and layering of developed technologies for overall effectiveness under varying experimental and environmental conditions.

(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 Tactical Technology PE 0602702E, Project TT-11					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Joint Logistics ACTDs TT-11	10.249	9.676	9.925	9.893	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) The Joint Logistics project is composed of two Advanced Concept Technology Demonstrations (ACTDs) that will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Global Combat Support System (GCSS). The focus area for the Joint Logistics ACTD (JL ACTD) addresses Commander-in-Chief (CINC) and Service requirements to develop JDST capability in the areas of Force Capability Assessment; Logistics Support Concept Generation and Evaluation; Distribution, Materiel Management, Maintenance Analysis; and Visualization. The second ACTD, the Joint Theater Logistics ACTD (JTL ACTD) integrates and expands those and other capabilities to provide real-time management and analysis tools for logistics and operations interoperability. Tools developed in this second ACTD are called Joint Theater Logistics Decision Support Tools (JTLDSTs) to distinguish them from the JDSTs developed for the JL ACTD and to emphasize the focus upon forces associated with a Joint Task Force in a theater of operations. JDSTs/JTLDSTs will use maturing technologies to provide warfighters and logisticians with the abilities to: assess support force capabilities to perform mission tasks; develop and evaluate logistics operational support plans; monitor logistics operations; and, react to deviations from projected support. These tools will exploit near real-time logistics data sources and will be available to all users via a web-based client-server environment that complies with defense information infrastructure (DII) common operating environment (COE) architecture standards and requirements. JTL tools will provide the fusion and correlation of plans and information for critical components of theater support, sustainment, and transportation systems providing effective management, analysis, and situational awareness to the logistics commanders. JTL capabilities will include real-time interoperability between logistics and operations during all phases of planning and execution. Key data sources include Joint Total Asset Visibility (JTAV), Joint Personnel Asset Visibility (JPAV), the Global Transportation Network (GTN), the Joint Operational Planning and Execution System (JOPES), and the Global Status of Readiness and Training System (GSORTS). This project will also provide a migration path for evaluating advanced technologies that are being developed by other projects such as the DARPA Advanced Logistics Technology Project (TT-10) and the Adaptive Course of Action Advanced Concept Technology Demonstration (PE0603750D). The JL and JTL ACTDs will support CINC/Joint Task Force (JTF) and Service/Agency logisticians across the entire operational spectrum -- mobilization, deployment, employment, sustainment and redeployment.

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(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Joint Logistics ACTD. ($ 10.249 Million)
  - Developed data access and mediation capability to pull information from disparate data sources and to share data and JDST data products between applications through a common user interface.
  - Expanded tool set functionality focusing on Component and Service needs. Derived and graphically displayed planned force capability estimates for logistics units throughout the deployment sequence at specific nodes over time.
  - Determined, evaluated, displayed, and compared logistics support concepts to include unit capabilities and select supply class requirements to support one or more operational courses of action.
  - Developed the framework to track and visualize the inventory status, flow, and consumption of sustainment stocks.

(U) FY 2000 Plans:

- Joint Logistics ACTD. ($ 4.838 Million)
  - Expand development of Joint Decision Support Tools (JDSTs) to compare planned logistics unit support capabilities with actual capabilities at specific nodes over time.
  - Develop the capability to generate a below-the-line logistics force structure based upon the operational course of action and demonstrate the capability to provide a qualitative force capability assessment of the force structure.
  - Exercise and demonstrate advanced JDST capabilities in an expanded joint warfighting exercise.
  - Transition proven JDST capability through the Advanced Information Technology Services (AITS) Joint Program Office (JPO) into the Global Combat Support System.

- Joint Theater Logistics (JTL) ACTD. ($ 4.838 Million)
  - Begin development of Joint Theater Logistics Decision Support Tools (JTLDSTs)
  - Start development of computer-assisted capabilities to evaluate operational and logistics tasks.
  - Initialize capability to calculate support unit requirements and sustainment and identify matching sources to meet mission requirements.

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- Incorporate logistics support capabilities and operational concepts into a single integrated view.
- Prepare to demonstrate JTL capabilities in a joint warfighting exercise.

(U) FY 2001 Plans:

- Joint Logistics ACTD. ($ 1.000 Million)
  - Transition Joint Decision Support Tools (JDST) capability through the Advanced Information Technology Services (AITS) Joint Program Office (JPO) into the Global Combat Support System.

- Joint Theater Logistics (JTL) ACTD. ($ 8.925 Million)
  - Expand JTLDST capability to integrate in-theater distribution support planning and infrastructure assessment, and to generate and compare alternative logistics support force concepts to support multiple operational courses of action. Track the execution of sourcing and sustainment from closure through dissemination throughout the theater.
  - Incorporate and enhance planned deviation detection technology and sentinels to compare planned resource requirements with near real-time operational logistic activity for select support items by location, provider, and intended consumer.
  - Develop capability to rapidly assess the impact of operational changes upon the logistics support structure. Develop a real-time in-theater management capability for critical resources including fuel and munitions, which integrates execution of logistics support plans with logistics and operational data feeds.
  - Develop the capability to forecast the impact of deviations and alternative support concepts upon future operations.
  - Demonstrate multi-echelon interoperability and in-theater management capabilities in a joint warfighting exercise.

(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 Integrated Command and Control Technology PE 0602708E, R-1 #18					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	38.315	38.126	31.761	0.000	0.000	0.000	0.000	0.000	N/A
Integrated Command and Control Technology IC-03	38.315	38.126	31.761	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This program element is budgeted in the Applied Research Budget Activity because it develops the technologies for high definition displays that are important for virtually all DoD applications that involve visual and graphic information. Major components of this program include: projection, head mounted and direct view displays based on multiple technologies; development of equipment and components required to manufacture advanced display technologies; and prototyping of display systems for system evaluation. These efforts will establish a domestic technical capability for the manufacture of components necessary for military systems that capture, process, store, distribute and display high-resolution images.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- High Definition Systems. ($ 25.861 Million)
  - Completed development of large organic-based and inorganic display technologies and continued development of flexible substrate displays for command and control applications.
  - Continued development of equipment and components to meet display cost and performance goals. This included efforts in printing and microreplication, field emission display materials, organic light emitting materials and phosphor technology development.
  - Completed first generation integrated display systems and system prototypes for mobile applications. Continued development of large screen command and control system prototypes, to include development of a large area, high resolution.

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- Flat Panel Display. ($ 5.794 Million)
  - Continued Flat Panel Display manufacturing equipment and materials.

- Flexible Emissive Displays. ($ 6.660 Million)
  - Demonstrated self-assembled fluidic transport on active matrix flexible backplanes.

(U) FY 2000 Plans:

- High Definition Systems. ($ 19.454 Million)
  - Develop flexible, rugged displays based on organic electroluminescence and zero-power reflective technology.
  - Develop active matrix backplanes on flexible substrates for high performance/low power rugged displays.
  - Develop enhanced maturing technologies (organic electroluminescence, field emission and flexible field substrates) to performance capabilities required for DoD applications.
  - Demonstrate/insert display technology into DoD systems to evaluate display technology.

- Flat Panel Displays. ($ 7.000 Million)
  - Continue Flat Panel Display manufacturing equipment and materials.

- Flexible Emissive Displays. ($ 11.672 Million)
  - Develop higher temperature plastic substrates compatible with display manufacturing.
  - Develop light emitting materials.
  - Demonstrate emissive monochrome display.

(U) FY 2001 Plans:

- Flexible Emissive Displays. ($ 12.000 Million)
  - Develop reduced water and oxygen substrate permeability.
  - Develop active matrix backplane transistors.

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 Integrated Command and Control Technology PE 0602708E, R-1 #18

- High Definition Systems. ($ 19.761 Million)
  - Integrate organic light emitting diodes on flexible, active matrix backplanes for increased brightness and reduced power. Integrate Field Emission and Phosphor Display Technologies.
  - Evaluate new display concepts for large, high-resolution displays.
  - Demonstrate/insert display technology into DoD systems for display evaluation.

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	39.607	31.296	32.000
Current Budget	38.315	38.126	31.761

(U) Change Summary Explanation:

FY1999 Decrease reflects minor repricing and SBIR reprogramming.
FY2000 Increase reflects congressional add for Flat Panel Displays, partially offset by the government-wide rescission.
FY2001 Decrease reflects minor repricing.

(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 Materials and Electronics Technology PE 0602712E, R-1 #19					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	268.595	242.267	249.812	230.267	215.275	218.571	230.594	Continuing	Continuing
Materials Processing Technology MPT-01	165.443	126.110	126.759	130.031	142.472	140.554	140.395	Continuing	Continuing
Microelectronic Device Technologies MPT-02	82.626	87.849	100.783	85.229	64.858	70.215	80.556	Continuing	Continuing
Cryogenic Electronics MPT-06	17.553	28.308	22.270	15.007	7.945	7.802	9.643	Continuing	Continuing
Military Medical/Trauma Care Technology MPT-07	2.973	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technology related to those materials, electronics, and biological systems that make possible a wide range of new military capabilities.

(U) The Materials Processing Technology project (MPT-0l) concentrates on the development of novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and enable new missions for military platforms and systems as well as to increase human performance. Areas of concentration include exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. This emphasis includes lightweight personnel protection, mesoscale machines for miniature devices, and ultra lightweight materials. The project also focuses on smart materials, sensors and actuators, functional materials and devices, advanced magnetic materials for non-volatile, radiation hardened magnetic memories, and electroactive polymers for sensing and actuating. Other areas of concentration include new materials concepts for portable power, development of bio-interface materials and methods, energy harvesting concepts, and frequency agile materials based on ferrite and ferroelectric oxides. This project also includes a biological systems thrust. The unique characteristics of biologically derived functional materials

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and devices will be exploited through the understanding and control of the structure and chemistry of the interface between man-made and biotic materials. In addition, emulation and/or control of biological functionality (i.e., sensing and mobility) will be explored for enhanced DoD applications (sensor, robotic, etc.).

(U) The Microelectronics Device Technologies project (MPT-02) develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics and infrared devices. Areas of emphasis include high-performance analog-to-digital converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This project includes a significant effort to develop advanced materials and device technology beyond the classical scaling limits of silicon device technology. A major initiative to explore the feasibility, design and development of information technology devices and systems utilizing non-silicon based materials and techniques is planned for initiation in FY 2001.

(U) In the Cryogenic Electronics project (MPT-06), thin-film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military applications. Thin-film high temperature superconducting components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance while reducing size and power requirements. Highly dependable and inexpensive cryocoolers (including thermoelectric coolers) are being developed for these applications, and expanded efforts will explore techniques to improve the performance of all solid state thermoelectric coolers as well as the overall cryogenic performance in applications ranging from communications to computing.

(U) **Program Change Summary:** (*In Millions*)	**FY 1999**	**FY 2000**	**FY 2001**
Previous President's Budget	278.286	235.321	219.063
Current Budget	268.595	242.267	249.812

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(U) Change Summary Explanation:

FY 1999 Decrease reflects IR 1415 reprogramming of the Laser Diode Array program to the Navy. Additional reductions were due to the Omnibus and SBIR reprogrammings.

FY 2000 Increase reflects Congressional adds for Materials in Sensors, Strategic Materials Manufacturing and Biodegradable Plastics programs (project MPT-01) and the 3-D Microstructures program (project MPT-02). These adds were partially offset by the Government-wide rescission and inflation reductions.

FY 2001 Increase reflects new efforts to develop biomimetic systems program (project MPT-01) and advanced materials for Beyond Silicon device technology development (project MPT-02).

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 Materials and Electronics Technology PE 0602712E, Project MPT-01					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Materials Processing Technology MPT-01	165.443	126.110	126.759	130.031	142.472	140.554	140.395	Continuing	Continuing

(U) Mission Description:

(U) The major goals of this project are to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and/or enable new missions for military platforms and systems.

(U) One important area of concentration is the exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. Thrusts in this area include new concepts for lightweight personnel protection, ultra lightweight materials, and multi-functional materials for lowering the weight and increasing the performance of aircraft and spacecraft structures. Approaches are also being developed for reducing the risk of using new materials in defense acquisitions. Smart materials, sensors and actuators for the control of the aerodynamic and hydrodynamic behavior of military systems are being developed and demonstrated to increase performance and lower detectability of aircraft, helicopters, and submarines as well as to increase human performance. "Intrinsically smart" materials that provide self-diagnosis and/or self-repair will be developed as well.

(U) Another major thrust is the development of functional materials and devices. This includes advanced magnetic materials for high sensitivity, magnetic field sensors; non-volatile, radiation hardened magnetic memories with very high density, short access time, infinite cycleability and low power; and electroactive polymers for sensing, actuating, and analog processing. Frequency-agile materials based on ferrite and ferroelectric oxides are being developed for tuned filters, oscillators, and antennas. New permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings, and actuators are also being explored.

(U) The mesoscopic size range ("sugar cube to fist") offers significant advantages in devices for defense. Efforts include mesopumps for battlefield sensors and mesocoolers for the individual soldier. Technology for the mask-less, direct-write of mesoscopic integrated conformal electronics will enable the three-dimensional integration of both active and passive components, significantly reducing the size, weight, and cost of integrated electronics functions (circuits, batteries, antennae, etc.).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
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(U) New materials and concepts for increasing the availability of portable power to the soldier are being investigated, as are approaches for deriving power for soldiers and sensors from the environment. These efforts will contribute to the design and fabrication of biohybrid devices. Structure and function emulated from biological systems will result in new biomimetic systems, which capture unique locomotion and sensing schemes.

(U) Finally, the unique characteristics of biologically derived functional materials and devices will be exploited through the understanding, control, and emulation of the structure and chemistry of the interface between man-made and biotic materials, and hybrid bioelectronics that electronically control biological organisms or use biological intelligence for smart materials. The interface between biologically inspired devices, electronics, and information processing will also be explored.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Structural Materials and Devices. ($ 32.500 Million)
  - Fabricated and tested materials and materials systems concepts designed to significantly improve personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round), dramatically increasing protection for the individual soldier.
  - Demonstrated solid freeform fabrication of titanium forging blanks.
  - Demonstrated spray forming of superalloy forging billets.
  - Demonstrated the use of solid freeform fabrication to upgrade distressed turbine vanes in man-rated gas turbine engines with ceramic composite components of high reliability.
  - Demonstrated initial feasibility, fabrication and performance of prototype mesoscale machines and components (e.g., miniature air blower, microcooler, meso pump, water purifier, etc.).
  - Demonstrated capability of sub-scale mesoscale pumping chambers to meet full-scale air blower design requirements.

- Smart Materials and Actuators. ($ 28.516 Million)
  - Demonstrated vortex wake reduction for submarines using smart materials.
  - Evaluated submarine acoustic noise reduction using smart materials pads and tiles.

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 Materials and Electronics Technology PE 0602712E, Project MPT-01

- Demonstrated a full-scale shape adaptive fighter inlet.
- Established growth conditions for large piezoelectric single crystals from flux using both open and closed crucible techniques.
- Evaluated the impact of piezoelectric single crystals on Navy low-frequency surveillance sonar, mid-frequency navigation/tactical sonar, and high-frequency weapons guidance sonar.

- Functional Materials and Devices. ($ 61.827 Million)
  - Demonstrated high speed, radiation hardened, medium density, and non-volatile magnetic memory utilizing magnetic multilayers; developed methods for controlling the microstructure of these giant magneto-resistive (GMR) films during growth.
  - Demonstrated a very high sensitivity magnetometer and gradiometer for localization of magnetic anomalies.
  - Demonstrated a permanent magnet material with a 20 percent higher strength (energy product).
  - Expanded the use of solid freeform fabrication to demonstrate a new process for the fabrication of silicon carbide devices and simple electronic component parts using rapid tool-less deposition processes.
  - Completed polymer development for infrared artificial dielectrics (IRADs).
  - Demonstrated the actuation capability of polymeric muscles.
  - Demonstrated a loss tangent less than 0.002 in hybrid ferrite/ferroelectric frequency agile filters.
  - Demonstrated a voltage-controlled oscillator (VCO) with an octave tuning range and low loss.
  - Demonstrated enhanced biological responses (molecular, cellular and organismal) at modified material interfaces. Identified approaches for the neurological control and behavior of simple biological systems through biomaterial development.
  - Demonstrated actuator materials and bioinspired control strategies for biomimetic locomotion systems; developed biomimetic systems that incorporate extremophile strategies for enhanced stability and performance in the environmental extremes required by the DoD.

- Energy and Environmental Sciences. ($ 24.600 Million)
  - Designed a low temperature, packaged direct oxidation fuel cell for soldier applications.
  - Demonstrated alternative energy sources (including thermal energy conversion) for portable battery chargers
  - Demonstrated energy harvesting concepts from ambient sources for unattended sensor applications.
  - Investigated fate and transport of chemicals in soil as well as chemotaxis schemes for localization of sources.
  - Demonstrated approaches to augment portable power sources by recovering energy from human activity.

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 Materials and Electronics Technology PE 0602712E, Project MPT-01

- Completed demonstration and insertion of advanced erosion/corrosion resistant and anti-fouling thin-film coatings in military systems.

- Seamless High Off-Chip Connectivity (SHOCC). ($ 5.000 Million)
  - Demonstrated the SHOCC concept in an advanced signal processor device in which a flip-chip digital signal processor is bump-bonded to an interposer layer.

- Nanophase Magnetic Materials. ($ 7.000 Million)
  - Continued research at the Advanced Materials Research Institute to demonstrate nanostructured magnetic materials for enhanced density magnetic media.

- Strategic Materials Manufacturing. ($ 2.000 Million)
  - Developed new manufacturing approaches for cutting tools for Defense strategic materials.

- Polymer Materials. ($ 4.000 Million)
  - Continued development of polymer materials and processing.

(U) FY 2000 Plans:

- Structural Materials and Devices. ($ 18.000 Million)
  - Integrate material concepts and materials systems into ultra-lightweight armor providing 100 percent improvement in personnel protection for the soldier.
  - Develop analytical, experimental, and simulation technologies for predicting the cost, performance, and life of advanced materials, decreasing the risk of and accelerating the time for insertion of new materials in Defense acquisitions.
  - Investigate concepts for the use of multifunctional materials in Defense applications (e.g., blast protection, thermal control) based on successes in ultra-lightweight metals and other structural materials programs.
  - Develop approaches for rapid design, optimization and assembly of small structures and devices based on solid freeform and rapid prototyping technologies.

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 Materials and Electronics Technology PE 0602712E, Project MPT-01

- Mesoscopic Structures and Devices. ($ 8.774 Million)
  - Demonstrate the operation of a mesoscopic pump array with flow rates of several liters/min. in one cubic inch.
  - Build and test an individual integrated mesoscopic cooler.
  - Demonstrate a mesoscopic vacuum pump integrated with a mass spectrometer on a chip.
  - Demonstrate the ability to directly write active and passive electronic materials and components at the mesoscale.

- Smart Materials and Actuators. ($ 25.000 Million)
  - Demonstrate improvements in aerodynamic performance through wind tunnel testing of wings with adaptive leading and trailing edge control surfaces.
  - Develop a “smart skin” for the reduction of self-noise and radiated noise in torpedoes.
  - Explore novel actuator schemes for enhancing the performance of soldiers or devices.
  - Demonstrate techniques to grow large (>3 cm) single crystals of relaxor piezoelectrics.
  - Demonstrate the performance of single crystal piezoelectrics in broadband ultrasonic imaging transducers.

- Functional Materials and Devices. ($ 44.000 Million)
  - Demonstrate very fast (<20 nsec access time), high density, radiation hardened magnetic memory circuits utilizing both giant magneto-resistance (GMR) multilayers and spin dependent tunneling devices; fully understand the micromagnetics of magnetic domain rotation in these devices.
  - Demonstrate very small, low power, high sensitivity magnetic gradiometers for the localization and identification of small ferrous objects.
  - Demonstrate permanent magnet materials with 50 percent higher magnetic strength (energy product) and the ability to preserve magnetic properties to temperatures over 500°C.
  - Demonstrate a loss tangent less than 0.002 in hybrid ferroelectric/ferrite (meta-material) devices.
  - Demonstrate a broadband 360-degree phase shifter with very low loss for antenna feed applications.
  - Demonstrate polymeric actuators that emulate the mechanical response and performance of human muscles.
  - Demonstrate green light-emitting diodes (LEDs) fabricated from electroactive polymers, with a half-life >5,000 hours; demonstrate blue and red LEDs with >1,000 hours half-life.
  - Select appropriate polymeric materials with electronic characteristics for field-effect transistor (FET) development.

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 Materials and Electronics Technology PE 0602712E, Project MPT-01

- Demonstrate growth of AlGaSb-InAs thin-films on GaAs substrates using the lateral epitaxial overgrowth technique.
- Demonstrate lattice mismatched epitaxial growth of dislocation free compound semiconductors using strain-absorbing layers.

- Bioinspired Materials and Devices. ($ 2.400 Million)
  - Explore sensormotory and navigational control schemes for biological systems through microelectronic interfaces.
  - Evaluate chemical, visual, and acoustic cues used by biological systems for controlled locomotion, behavior, and distribution.

- Advanced Energy Technologies. ($ 15.436 Million)
  - Demonstrate and field test compact portable power systems in soldier applications.
  - Develop high efficiency direct thermal to electric energy conversion.
  - Demonstrate (in the laboratory) power generation from the environment capable of operating unattended ground sensors.
  - Investigate novel concepts for small-scale, near ambient temperature, chemical power generation.

- Materials in Sensors. ($ 9.500 Million)
  - Continue work in materials and processing, including investigation of novel polymer and inorganic sensor and sensor protection schemes.

- Biodegradable Plastics. ($ 1.000 Million)
  - Initiate an effort to examine biodegradable plastics for Defense applications.

- Strategic Material Manufacturing. ($ 2.000 Million)
  - Continue the effort to develop new manufacturing approaches for cutting tools used for Defense strategic materials.

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 Materials and Electronics Technology PE 0602712E, Project MPT-01

(U) FY 2001 Plans:

- Structural Materials and Devices. ($ 20.200 Million)
  - Demonstrate ultra-lightweight armor with 100 percent improvement over current materials and begin transition of manufacturing/design capabilities to the Army.
  - Demonstrate the use of multifunctional materials to provide significant improvement in the capabilities of defense systems by providing additional functions (e.g., self-healing, thermal control, blast protection, power) to load bearing structure.
  - Continue the optimization of analytical, experimental, and simulation technologies for predicting the properties of advanced polycrystalline, nanocrystalline, and amorphous materials.
  - Select specific material(s) of high value to a DoD system for demonstration of accelerated insertion concepts.

- Mesoscopic Structures and Devices. ($ 12.200 Million)
  - Demonstrate initial, one-dimensional mesoscopic gyroscope operation that has drift rates <0.5°/hr.
  - Demonstrate fully functional integrated mesoscopic coolers that exhibit a coefficient of performance >4.
  - Demonstrate that direct-write mesoscale active and passive components have functionality close to discrete surface mount components.
  - Demonstrate the ability to direct-write mesoscale passive components (resistors, capacitors) and antennas on conformal surfaces.

- Smart Materials and Actuators. ($ 24.800 Million)
  - Complete wind tunnel test verification of an active aircraft engine inlet enabling a 20 percent increase in aircraft mission radius compared to a conventional fixed geometry inlet design.
  - Complete water tunnel test of a subscale submarine propulsor with active control to reduce acoustic radiation levels.
  - Complete flight test of a rotorcraft with blades containing integral actuators and flaps for control of noise and vibration.
  - Explore techniques that use the intrinsic response of a material to its operating environment to provide diagnosis of the performance life of the material.
  - Develop approaches for integrating actuators, power systems and control methods to affect lightweight, energy efficient actuators for enhancing the performance of soldiers or devices.
  - Demonstrate methods to fabricate multilayer actuators made from single crystals of relaxor piezoelectrics.
  - Demonstrate the performance of single crystal piezoelectrics in an advanced Navy sonar transducer.

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 Materials and Electronics Technology PE 0602712E, Project MPT-01

- Functional Materials and Devices. ($ 44.212 Million)
  - Demonstrate a prototype, very high effective density (>16 Mbit), high speed (<10 nsec access time) magnetic memory circuit based on giant magneto-resistance (GMR) or spin-dependent tunneling utilizing very low power and low voltage (<2.5 volts).
  - Design a prototype slotless integral motor/pump with advanced magnetic materials for improved efficiency and performance.
  - Demonstrate a steerable ferroelectric lens for phased array radar.
  - Demonstrate a conformal, frequency agile antenna that is 100x cheaper than conventional technology.
  - Explore applications of meta-materials for advanced electromagnetic devices (e.g., antennas).
  - Demonstrate electronic mobility of $>10^{-4}$ cm^2/Vs in electroactive polymeric materials.
  - Demonstrate advantages of polymer based actuators in specific Defense applications (e.g., robotics, sonar).
  - Demonstrate the use of electroactive polymers as thin-film spatial filters for quasi-real-time multispectral image analysis for enhancing target detectability.
  - Fabricate a preamplifier for a millimeter wave radar front end with a 4-dB improvement in sensitivity using lateral epitaxial overgrowth fabrication capabilities.
  - Demonstrate the use of twist bonded substrates for integration of an infrared focal plane with integrated read-out electronics.
  - Demonstrate scale-up capability for single crystal growth utilizing x-ray interference patterns to template crystal growth.

- Bioinspired Materials and Devices. ($ 5.100 Million)
  - Identify candidates for advanced sensor systems that incorporate biologically inspired concepts including self-calibration, self-healing, variable temperature operation, functional responsiveness, and mobility.
  - Construct prototype microelectronic interfaces for control of biological systems.

- Advanced Energy Technologies. ($ 15.247 Million)
  - Demonstrate energy harvesting from the environment for unattended sensor and soldier applications.
  - Demonstrate (in the laboratory) high efficiency direct thermal to electric energy conversion operating on a hydrocarbon fuel.
  - Develop specific approaches for small, chemical power generation that operates at near ambient temperatures.
  - Investigate novel ultra-high energy density power source concepts.

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 Materials and Electronics Technology PE 0602712E, Project MPT-01

- Bio:Info:Physical Systems Interface. ($ 5.000 Million)
  - Create new families of catalysts and pathways for synthesizing compounds and materials biomimetically.
  - Explore new architectural components and assembling principles of biological systems and develop new artificial matrices and assembling processes.
  - Develop new materials and matrices for sensing, actuation, and computation via biologically inspired routes to material synthesis.

(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 Materials and Electronics Technology PE 0602712E, Project MPT-02					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microelectronic Device Technologies MPT-02	82.626	87.849	100.783	85.229	64.858	70.215	80.556	Continuing	Continuing

(U) Mission Description:

(U) This project develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics, and infrared devices. Areas of emphasis include high performance Analog-to-Digital (A/D) converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. In addition, this project develops and demonstrates advanced microelectronics technology for DoD critical needs including digital radar receivers and acoustic-electronic components. Technologies developed in this project are performance driven and exceed commercial capabilities.

(U) The phenomenal progress in current electronics and computer chips will face the fundamental limits of silicon technology in the early 21st century, a barrier that must be overcome in order for progress to continue. The Beyond Silicon program will explore alternatives to silicon based electronics in the areas of new electronic devices, new architectures to use them, new software to program the systems, and new methods to fabricate the chips. Approaches include nanotechnology, nanoelectronics, molecular electronics, spin-based electronics, quantum computing, new circuit architectures optimizing these new devices, and new computer and electronic systems architectures.

(U) The Beyond Silicon program will investigate the feasibility, design, and development of powerful information technology devices and systems using approaches to electronic device designs that extend beyond traditional Complementary Metal Oxide Semiconductor (CMOS) scaling, including non-silicon based materials technologies, to achieve low cost, reliable, fast, and secure computing, communication, and storage systems. This investigation is aimed at developing new capabilities; from promising directions in the design of information processing components using both inorganic and organic substrates, designs of components and systems leveraging quantum effects and chaos, and innovative approaches to computing designs incorporating these components for such applications as low cost seamless pervasive computing, ultra-fast computing, and sensing and actuation devices.

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 Materials and Electronics Technology PE 0602712E, Project MPT-02

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Advanced Microelectronics (AME). ($ 7.741 Million)
  - Characterized candidate 25-nm transistors $(150nm)^2$ total area and established process sequence for chip for proof-of-principle demonstration.

- Digital Receiver Technology. ($ 10.466 Million)
  - Developed advanced digital processor components.

- High Power Electronics. ($ 1.800 Million)
  - Continued development of silicon carbide (SiC) materials for High Power Electronic Switching Devices increasing wafer diameter and lowering defect density. Explored new concepts for integration of multiple materials on silicon chips.

- High Powered Solid State Electronics. ($ 6.664 Million)
  - Demonstrated high current density (>100 A/cm^2) 1000-V-class SiC high power switch; demonstrated high-temperature (>250 C) operation of a 1000-V-class switch.

- Very Large Scale Integrated (VLSI) Photonics. ($ 19.033 Million)
  - Demonstrated integrated 8x8 VLSI photonics chip (laser, detector and electronics) and optoelectronic modeling tools compatible with electronic CAD tools and demonstrated the feasibility of using molecular self-assembly techniques to position optoelectronic devices with high precision on silicon (Si) circuits.

- Acoustic Micro-Sensors. ($ 7.616 Million)
  - Carried out full sonoelectronic integration, combining surface micromachined transducer arrays, low-noise CMOS electronic readout, acoustic lens and packaging technology, and low-power display technology to fabricate high resolution underwater imager.

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 Materials and Electronics Technology PE 0602712E, Project MPT-02

- HERETIC. ($ 4.749 Million)
  - Demonstrated heterostructure integrated thermoelectric (TE) or thermionic devices having the same heat-removal capacity as the best Commercial Off-The-Shelf (COTS) TE coolers; fabricated micro-jets, micro-nozzles or micro-thermionic emitters capable of monolithic integration with Si circuits.

- Materials Integration. ($ 3.732 Million)
  - Explored new concepts in technology for integrating various materials on substrates.

- Reconfigurable Aperture (RECAP). ($ 8.565 Million)
  - Twelve contracts awarded to address specific core technologies including microelectromechanical systems (MEMS), photonic bandgap materials, multi-layer substrate integration, optical control circuits, frequency selective materials and artificial magnetic conductors. Design and analysis initiated.

- 3-D Microelectronics. ($ 5.500 Million)
  - Continued development of key technologies behind a packaging concept that uses a stacked multichip module (MCM) approach to reduce interconnect length and increase physical connectivity between layers of electronics.

- MEMS Deep Etching. ($ 6.760 Million)
  - Initiated MEMS Deep Etching project in conjunction with Army Research Laboratory.

(U) FY 2000 Plans:

- Reconfigurable Aperture (RECAP). ($ 9.576 Million)
  - Design, model, and fabricate Reconfigurable Antenna components employing MEMS, Photonic Bandgap materials, Frequency Selective Surface materials, artificial magnetic conductors, and optical control circuits. Develop and demonstrate integration technologies including advanced control techniques, broadband tunable ground planes, and multilayer packaging technologies.

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 Materials and Electronics Technology PE 0602712E, Project MPT-02

- Digital Receiver Technology. ($ 3.945 Million)
  - Demonstrate a very high performance analog-to-digital (A/D) converter with 14 effective bits, 60 MHz instantaneous bandwidth, and >86 dB spurious free dynamic range (SFDR) in FY 2000 with potential for multiple military applications.

- High-powered Solid State Electronics. ($ 2.934 Million)
  - Demonstrate high-current density (>100 A/cm^2) 2500-V class switch from silicon carbide (SiC); demonstrate 2500-V rectifier diode from gallium-nitride (GaN).

- Sonoelectronics. ($ 7.986 Million)
  - Complete sonoelectronic camera prototype fabrication; carry out laboratory characterization and test-tank evaluation.
  - Demonstrate the lab-proven imager in a very-shallow-water (VSW) field setting.

- Acoustic Micro-Sensors. ($ 2.632 Million)
  - Initiate air-coupled acoustic microsensor project to demonstrate chip-scale sensor system capable to locate, track, and identify a sound source or a voice in a noisy environment.

- HERETIC. ($ 9.727 Million)
  - Complete integration of Heterostructure Integrated Thermoelectronic (HIT) device arrays with bias and control circuitry on GaAs substrates; complete integration of micro-jet, micro-nozzle or micro-thermionic arrays with bias and control circuitry over Si substrates.

- Advanced Microelectronics (AME). ($ 9.733 Million)
  - Demonstrate circuit and modeling of a full-scale system (e.g. image processing system) featuring terascaled-compatible devices and associate technology far beyond the existing industry roadmap.

- VLSI Photonics. ($ 19.454 Million)
  - Develop VLSI heterogeneous integration technology and integrate micro-opto-mechanical components with VLSI chips; develop system-level CAD tools.

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 Materials and Electronics Technology PE 0602712E, Project MPT-02

- Materials Integration on Silicon. ($ 10.911 Million)
  - Initiate an integration program that develops a tool kit of materials and processes for integration of multiple materials onto a single silicon substrate.

- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 8.951 Million)
  - Initiate program to begin a major development in photonics, using both wavelengths – wavelength optics – as well as spatial attributes of light – bulk optics.

- 3-D Microelectronics. ($ 2.000 Million)
  - Continue development of key technologies behind a packaging concept that uses a stacked MCM approach to reduce interconnect length and increase physical connectivity between layers of electronics.

(U) **FY 2001 Plans:**

- Reconfigurable Aperture (RECAP). ($ 17.097 Million)
  - Integrate and assemble component technologies to subarrays. Demonstrate reproduceable fabrication and reconfigurability. Continue successful core technologies and initiate contracts for integrated system applications demonstrations.

- Digital Receiver Technology. ($ 4.000 Million)
  - Develop 16 Effective bit, 100 MHz bandwidth A/D converter.

- Acoustic Micro-Sensors. ($ 5.953 Million)
  - Demonstrate MEMs-based 3-D acoustic transducers and/or transducer arrays with superior sensitivity, signal-to-noise ratio, and bandwidth that is current state-of-the-practice.

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 Materials and Electronics Technology PE 0602712E, Project MPT-02

- HERETIC. ($ 8.940 Million)
  - Demonstrate HIT devices on GaAs having better specific heat-removal capacity as the best commercial-off-the-shelf TE coolers; demonstrate micro-jets, micro-nozzles, or micro-thermionic emitters on Si having much better heat-removal capacity as the best convective air or liquid cooling systems.

- VLSI Photonics. ($ 8.940 Million)
  - Demonstrate Synthetic Aperture Radar (SAR) processor using VLSI Photonics technologies; showcase reconfigurable cross-connect switching. Demonstrate rapid parallel access to memory using optical interconnection.

- Material Integration On Silicon. ($ 9.934 Million)
  - Continue integration of new material and processes into a single silicon substrate that will drive system performance. Demonstrate logic circuits and power amplifiers on silicon substrates.

- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 10.919 Million)
  - Continue component development, integration, algorithms, architectures and sub-system functionality demonstrations.
  - Demonstrate emitters and detectors in the spectral band 350-500 nm.

- Beyond Silicon. ($ 35.000 Million)
  - Development of design and fabrication of low-cost, reliable computational devices and systems in non-silicon substrates; development of printable circuits, and programming methodologies to obtain desired system behavior from unreliable devices.
  - Investigate the development of quantum information technology for use in secure communications and ultra-fast information manipulation.
  - Investigate computational mechanisms in biological substrates, and the interface with other substrates to obtain novel sensing and control mechanisms.
  - Investigate the application of photonic interconnects for on-chip information communication.
  - Demonstrate non-silicon based transistors technologies based on low bandgap materials capable of multi-gigahertz operation at bias voltages < 1 volt.

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 Materials and Electronics Technology PE 0602712E, Project MPT-02

- Demonstrate nanostructured materials for quantum based electronic and optoelectronic device applications.
- Demonstrate an all semiconductor spin filter for injection of spin polarized electrons at room temperature.
- Demonstrate a three terminal spin dependent resonant tunneling device operating at several hundred Ghz.
- Demonstrate room temperature, reversible scalable molecular memory at the density of a terabit /mm3.
- Demonstrate room temperature, scalable molecular logic gates that produce the correct truth table.

(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 Materials and Electronics Technology PE 0602712E, Project MPT-06					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Cryogenic Electronics MPT-06	17.553	28.308	22.270	15.007	7.945	7.802	9.643	Continuing	Continuing

(U) Mission Description:

(U) Thin-film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films may be deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for optimum performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include upgraded ship-defense radar (SPQ-9B) with 100X greater detectability of missiles in littoral clutter and communications receivers with greater immunity to interference. Highly dependable and inexpensive cryocoolers are also being developed for these applications. These latter development efforts include the exploration of techniques to improve the performance of solid-state thermoelectric materials and devices in applications ranging from communications to power generation.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Cryogenics Technologies. ($ 8.093 Million)
  - Inserted cryogenic packages in communication transceivers that mitigate electromagnetic interference effects.
  - Demonstrated SIGINT (Signals Intelligence) applications in aircraft and on the ground, showing range enhancement due to cryogenics.

- Multitechnology Integration in Mixed-Mode Electronics (MIME). ($ 4.960 Million)
  - Demonstrated a tunable bandpass filter in the 800-900 MHz range, using a combination of high-temperature superconductivity and micro-electro-mechanical technologies, with Q>5,000 and frequency shift >5%, retaining sensitivity enhancement with tunability.

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 Materials and Electronics Technology PE 0602712E, Project MPT-06

- Thermoelectric Materials and Devices. ($ 4.500 Million)
  - Demonstrated thermoelectric cooling materials that can achieve 100°C cooling in three stages as compared to the current seven stages.
  - Demonstrated potential benefit of efficient power generation from thermoelectric devices operating at high temperature (>500°C).

(U) FY 2000 Plans:

- Cryogenics Technologies. ($ 23.995 Million)
  - Develop devices and components, based upon superconducting and other electromagnetic materials that in a cryogenic environment would provide a 5-10X-range improvement over conventional means for detection of low-level signals.
  - Complete adaptation of cryocoolers in microelectronics packages for communications transceivers.
  - Expand efforts in mixed-mode electronics technology development to include tunable high temperature superconducting filters that preserve high-Q, with 10% tunability.

- Thermoelectric Materials and Devices. ($ 4.313 Million)
  - Demonstrate thermoelectric cooling materials that can achieve 100°C cooling in two stages or less.
  - Demonstrate a thermoelectric converter with a factor of two improvements in power generation per unit size.

(U) FY 2001 Plans:

- Cryogenics Technologies. ($ 22.270 Million)
  - Fabricate a cryogenic module, operating as a front-end pre-selector, to enhance the sensitivity of a receiver to detect low-level emitters in the presence of multiple interferors.
  - Design a complete cryogenic receiver module, incorporating tunable high temperature superconducting (HTS) antenna/pre-selector and digital microelectronics (with HTS embedded passives), displaying unsurpassed sensitivity and interference rejection.

(U) Other Program Funding Summary Cost:

- 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 Materials and Electronics Technology PE 0602712E, Project MPT-06

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	0.000	17.071	26.821	32.700	40.000	40.986	43.986	Continuing	Continuing
Advanced Aerospace Systems ASP-01	0.000	17.071	26.821	32.700	40.000	40.986	43.986	Continuing	Continuing

(U) Mission Description:

(U) The Advanced Aerospace Systems program element (PE) is budgeted in the Advanced Technology Development budget activity because it will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical and space systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. This new PE was created to satisfy an Agency requirement for a dedicated host for aerospace research that has progressed beyond the applied research stage and no longer belongs in the 6.2 based Tactical Technology program element (PE 0602702E). Two of the three initial programs in FY 2000 are outgrowths from this PE.

(U) The Supersonic Miniature Air-Launched Interceptor (MALI) program will demonstrate an inexpensive supersonic air platform with a low cost uncooled infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. As a further cost reduction, the program will leverage off the existing miniature air-launched decoy (MALD) program's technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities (MALD was funded in FY 1999 from Project TT-06, PE 0602702E). An advanced unmanned air vehicle avionics development and emerging payload effort will be incorporated into the MALI core program due to the required data transmit/receive survivability configuration of the interceptor mission.

(U) The Navy and the Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicles (UAV) to support dispersed units in littoral and urban areas. DARPA, in partnership with the Office of Naval Research (ONR) and industry, have formulated the Advanced Air Vehicle (AAV) program to explore two innovative vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and flight test of this scaled vehicle concept will

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32

be conducted to validate the command and control, stability and control system and aerodynamic performance required for vertical take-off, landing (VTOL) and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL unmanned air vehicle (UAV) with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2000nm) and endurance (>24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance.

(U) The Orbital Express Space Operations Architecture program will develop and demonstrate robotic techniques for on-orbit preplanned electronics upgrade, refueling and reconfiguration of satellites that could support a broad range of future U.S. national security and commercial space programs. An important element of the program is the enabling nature of such capability for new space missions and its potential to reduce space program costs through spacecraft life extension ("Pre Planned Product Improvement," or "P3I"), comparable to what is done today with aircraft. During Phase I (Concept Definition) the type of satellite servicing to be emulated in the on-orbit demonstration will be identified (to include the type of hardware upgrades and reconfiguration to be supported, and the techniques to be adopted in transferring hardware and fuel between spacecraft), and detailed designs will be developed for "industry standard," nonproprietary satellite-to-satellite mechanical and electrical interfaces enabling on-orbit hardware and fluid transfers. In Phase II, preliminary system design will emerge in conjunction with developments in software and sensors necessary for robotic space operations; and the technical feasibility and affordability of using water, or other new or innovative fuel or fuel stock, will be assessed as a potentially significant cost savings for space operations. In Phase III, detailed design of the on-orbit demonstration spacecraft (the service vehicle, the demonstration "target," or serviced satellite, and the depot for replacement hardware and fuel) will occur; and the spacecraft will be fabricated, integrated, ground tested, and space-qualified. Finally, in FY 2004, the demonstration spacecraft will be launched. On-orbit, the Orbital Express spacecraft will repeatedly demonstrate the feasibility of roboticly upgrading, refueling and reconfiguring satellites. (The FY 2001 funding of this program's technology development is exploiting the development of advanced tactical technology concepts and compact laser technologies (approximately $5 million) funded under PE 0602702E, Project TT-06 in FY 2000 as well as other efforts in this Project, ASP-01.)

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32

(U) FY 2000 Plans:

- Advanced Air Vehicle (AAV). ($ 9.453 Million) [Future Combat Systems – related = $5.000 Million]
  - Continue fabrication and conduct hardware in the loop and ground testing of Canard Rotor/Wing (CRW) and A160 concepts.
  - Complete fabrication of two A160 prototypes and conduct ground and flight tests.

- Supersonic Miniature Air-Launched Interceptor (MALI). ($ 4.336 Million)
  - Conduct engine and low cost miniature sensor and advanced payload testing.
  - Fabricate, assemble and conduct ground and early risk reduction testing of air vehicle.
  - Develop airborne inter-vehicle communications, mission processing and execution.
  - Initiate detail test planning for flight demonstration of interceptor and collaborative formation mission.
  - Explore other concepts for low cost MALI/MALD airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

- Orbital Express Space Operations Architecture. ($ 3.282 Million)
  - Conduct mission utility, cost and cost effectiveness trade studies and analyses. Develop preliminary on-orbit demonstration test plan and program risk assessment and mitigation plan. Identify key enabling technologies, and develop a technology development plan.
  - Select industry proposed baseline mission and satellite-to-satellite interface concepts.
  - Conduct a system requirements review.
  - Develop competing detailed interface designs.

(U) FY 2001 Plans:

- Advanced Air Vehicle (AAV). ($ 2.978 Million)
  - Complete Canard Rotor/Wing (CRW) fabrication and conduct ground and flight tests.
  - Continue flight tests of A160 air vehicle.
  - Design sensor integration modifications to A160 air vehicle.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32

- Supersonic Miniature Air-Launched Interceptor (MALI). ($ 6.958 Million)
  - Continue air vehicle fabrication, assembly and conduct ground testing.
  - Demonstrate airborne inter-vehicle communications, mission processing and execution.
  - Perform supersonic engine flight verification and seeker/advanced payload verification.
  - Conduct flight demonstration of supersonic vehicle interceptor and collaborative formation flying mission.
  - Continue to explore other concepts for low cost MALI/MALD airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

- Orbital Express Space Operations Architecture. ($ 16.885 Million)
  - Select detailed design for standard (non-proprietary) satellite-to-satellite electrical and mechanical interfaces.
  - Develop competing preliminary system designs.
  - Complete on-orbit demonstration test plan, program risk assessment and mitigation plan, and technology development plan.
  - Conduct a second system requirement review and preliminary design review.
  - Select demonstration system preliminary design.
  - Begin detailed final system design.
  - Initiate development of key enabling technologies/subsystems.

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	0.000	19.664	19.000
Current Budget	0.000	17.071	26.821

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects congressional reduction for MALI and the government-wide rescission.

FY 2001 Increase reflects expansion of the Orbital Express Space Operations Architecture effort and completion of flight tests of A160 air vehicle.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Apr 00	Advanced Air Vehicle (AAV): Flight test A160 air vehicle.
May 00	AAV: CRW Detailed Design Review.
Jun 00	MALI: Perform engine critical design review.
Aug 00	AAV: Complete A160 flight control system testbed flights.
Aug 00	MALI: Perform Critical Design Review (CDR) after conducting performance trades.
Sep 00	Orbital Express Space Operations Architecture (OESOA): Complete concept definition and mission utility analysis. Select baseline mission and satellite-to-satellite interface concepts.
Sep 00	AAV: Complete CRW ground testing.
Sep 00	MALI: Perform seeker captive carry flight-testing.
Nov 00	OESOA: Complete on-orbit demonstration test plan, and program risk assessment and mitigation plan.
Dec 00	MALI: Complete vehicle recovery system demo.
Jan 01	MALI: Complete engine altitude chamber testing.
Jan 01	Orbital Express Space Operations Architecture (OESOA): Conduct system requirement review.
Mar 01	Miniature Air-Launched Interceptor (MALI): Deliver first supersonic engine.
Mar 01	MALI: Complete avionics environment verification testing.
May 01	MALI: Conduct subsonic flight readiness review/supersonic CDR.
Jun 01	MALI: Perform formation flight demo.
Jun 01	OESOA: Preliminary Design Review.
Aug 01	MALI: Perform intercept flight demonstration.
Aug 01	Advanced Air Vehicles: Complete flight tests of both Canard Rotor/Wing and A160 vehicles.
Oct 01	MALI: Complete installed engine testing.
Oct 01	MALI: Conduct flight readiness review.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32

Jan 02 OESOA: Critical Design Review.
Jan 02 MALI: Perform supersonic flight demonstration.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, R-1 #40				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	260.296	252.388	191.800	188.264	173.867	163.354	149.954	Continuing	Continuing
Uncooled Integrated Sensors MT-03	12.803	10.732	11.916	6.930	0.000	0.000	0.000	0.000	N/A
Electronic Module Technology MT-04	61.437	55.153	43.684	45.772	48.067	38.029	36.829	Continuing	Continuing
Tactical Information Systems MT-05	31.519	20.668	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Microwave and Analog Front End Technology MT-06	3.809	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Centers of Excellence MT-07	6.062	5.478	4.000	0.000	0.000	0.000	0.000	0.000	N/A
Manufacturing Technology Applications MT-08	20.685	18.564	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Advanced Lithography MT-10	48.026	44.791	45.012	45.013	45.000	44.000	45.000	Continuing	Continuing
MEMS and Integrated Micro-systems Technology MT-12	75.955	74.711	37.712	37.590	24.000	24.025	10.825	Continuing	Continuing
Mixed Technology Integration MT-15	0.000	22.291	49.476	52.959	56.800	57.300	57.300	Continuing	Continuing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, R-1 #40

(U) Mission Description:

(U) The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and process technologies for the production of various electronics and microelectronic devices, sensor systems, actuators and gear drives that have military applications and potential commercial utility. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements and enhance the US industrial base.

(U) The Uncooled Integrated Sensors project addresses a long-standing Defense requirement for uncooled infrared sensor arrays for major weapons systems that cannot accommodate costly cryogenic cooling packages.

(U) The Electronic Module Technology project is a broad initiative to decrease the cost and increase the performance of weapon systems through the insertion of electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components.

(U) Advanced Lithography technology has enabled the dramatic growth of integrated circuit capability. Advances have led to improvements in electronic and computing systems performance in terms of speed, power, weight and reliability. Further improvements require microcircuits with smaller features to meet the operational seed, power, weight and volume constraints.

(U) The Microelectromechanical Systems (MEMS) project is a broad and cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical systems. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards and physiological states.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, R-1 #40

(U) The goal of the Mixed Technology Integration project is to revolutionize the integration of mixed technologies at the micrometer/nanometer scale. This will produce low-cost, lightweight, low-power 3-D microsystems that improve battlefield awareness and the operational performance of military platforms. This project will leverage industrial manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way warfighters see, hear, taste, smell, touch and control environments.

(U) Three on-going DARPA projects are nearing completion. Both the Tactical Information Systems (MT-05) and the Manufacturing Technology Applications (MT-08) projects end in FY 2000. The Tactical Information Systems project is designing and developing prototype modules, using core technologies that sense, think and communicate, and integrating them into selected personal information products. The project is also demonstrating the feasibility of combining real-time visual images of the environment with geospatially registered computer generated information for use by individual mounted and dismounted warfighters. The Manufacturing Technology Applications project goal is to reduce the cost and acquisition lead-time of future military systems by integrating manufacturing process considerations during the product design phase and by demonstrating high efficiency multi-product prototype factories. This project enables manufacturers to economically produce military variants of their commercial products in limited quantities through the introduction of flexible process technologies. The Centers of Excellence (MT-07) project finances demonstration, training and deployment of advanced manufacturing technology. This effort will transition to state/private support during FY 2001.

(U) **Program Change Summary:** (*In Millions*)	**FY 1999**	**FY 2000**	**FY 2001**
Previous President's Budget	265.442	246.023	233.198
Current Budget	260.296	252.388	191.800

(U) Change Summary Explanation:

FY 1999 Decrease reflects a reduction due to the Omnibus and SBIR reprogrammings.

FY 2000 Increase reflects the Congressional adds to Change Detection Technology, Defense TechLink Center, Laser Plasma X-ray Source Technology, Point Source Lithography Technology and CAMD programs. Funding for the Tactical Information Systems project was moderately increased to accelerate completion of the effort. Offsetting these increases was a Congressional reduction to the Robotics program and a government-wide rescission.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, R-1 #40

FY 2001 Decrease reflects the transition of the MEMS insertion efforts from the component-oriented Devices and Processes/Reliability program to specific programmatic applications and the completion of the Tactical Information Systems and Manufacturing Technology Applications projects.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2000
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technology; PE 0603739E, Project MT-03

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Uncooled Integrated Sensors MT-03	12.803	10.732	11.916	6.930	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) The Uncooled Integrated Sensors project addresses the technology necessary to produce affordable, infrared sensor arrays essential to major weapon systems. The focal plane array consists of a two-dimensional detector array sensitive in a broad spectral range, integrated with unique signal processing to enhance performance and provide more efficient utilization of the information. The critical elements of the technology addressed in this program include the infrared material, detector array fabrication, read-out electronics, cryogenic packaging and testing, and module assembly. Processing and fabrication techniques focus on the production of affordable arrays, at low volume, in the configurations required by weapon systems. Performance enhancements in uncooled infrared and near-infrared sensors are also being addressed to provide an integrated, broadband two dimensional sensor array without the cryogenic package usually associated with infrared sensors. Thermal Imaging Devices will develop new imaging at the theoretical limit, (five to fifty times increase over current uncooled devices), achieving high performance in extremely small, low power configurations and demonstrating technology to open new applications for imaging devices.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Uncooled Imaging Sensors. ($ 10.150 Million)
  - Demonstrated uncooled infrared array with thermal sensitivity of 0.05^{o} C.
  - Demonstrated low power micro-bolometer sensor for unattended ground sensors.
  - Fabricated and tested uncooled infrared arrays and low power solid state low light level arrays.

- Thermal Imaging Devices. ($ 2.653 Million)
  - Fabricated and evaluated microstructures with thermal isolation properties five to ten times less than current thermal devices.

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(U) FY 2000 Plans:

- Uncooled Imaging Sensors. ($ 2.732 Million)
  - Demonstrate 480x640 uncooled arrays with < .05 milli-kelvin, 1 mil pixel.
  - Transfer 480x640 uncooled infrared sensor to Army missile seeker program.
  - Conduct field evaluation of high sensitivity uncooled infrared sensor with low light sensor for ground operations.

- Thermal Imaging Devices. ($ 8.000 Million)
  - Demonstrate non-contact read-out devices and characterize sensitivity/noise sources.
  - Demonstrate non-contact imaging array with thermal sensitivity of 100 milli-kelvin.

(U) FY 2001 Plans:

- Thermal Imaging Devices. ($ 11.916 Million)
  - Demonstrate 100 gram imaging sensor with performance acceptable for micro-air-vehicles.
  - Optimize read-out structure to read signals with short (approx. 1 msec.) integration time.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-03

(U) Schedule Profile:

Plan	Milestones
Mar 00	Demonstrate non-contact read-out devices and characterize sensitivity/noise sources.
Sept 00	Field evaluation of high sensitivity uncooled sensor with low light level sensor for ground operations.
Nov 00	Demonstrate 100 gram imaging sensor with performance acceptable for micro-air-vehicles.
Sept 01	Demonstrate 50-gram sensor with sensitivity of 20 milli-kelvin.
Jan 02	Incorporate high responsitivity materials into detector structure.
Mar 02	Integrate materials and microstructure into imaging device.
Sept 02	Demonstrate five-gram sensor with sensitivity <5milli-kelvin, ideal thermal imaging device.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Electronic Module Technology MT-04	61.437	55.153	43.684	45.772	48.067	38.029	36.829	Continuing	Continuing

(U) Mission Description:

(U) The Electronic Module Technology Project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards, and emerging technologies such as high density Multichip Modules.

(U) The project has four major objectives: (l) shorten the overall design, manufacture, test and insertion cycle for advanced electronic subsystems; (2) advance the state-of-the-art in electronic interconnection and physical packaging technology to allow circuits to operate close to their intrinsic maximum speed with less overhead in terms of volume, weight and cost; and (3) provide a robust manufacturing infrastructure for electronic modules.

(U) The project has the following major elements: Photonic Analog/Digital (A/D) Conversion; Distributed Robotics; Design Support for Mixed Technology Integration (Composite CAD) and the Molecular-level Large-area Printing (MLP) program. Photonic Analog/Digital (A/D) conversion will utilize breakthrough photonic developments to substantially increase the speed by which analog signals are converted into digital data streams for data reduction and processing. Distributed Robotics is an effort to integrate developments in Microelectromechanical Systems (MEMS), power sources, communications and advanced microelectronics to design, construct and field multiple, high-performance, mobile, autonomous systems. Composite CAD seeks to develop the design tools (concept exploration, analysis, optimization and verification) to allow thousands of analog, digital, optical, MEMS and microfluidic devices to be integrated into “systems-on-a-chip” and other highly integrated mixed technology systems. The MLP program is exploring approaches to ‘print’ MEMS devices on large surfaces.

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(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- OMNET. ($ 11.682 Million)
  - Demonstrated integrated optoelectronic transceivers and optical switches for reconfigurable interconnections of sensors to processors.
  - Demonstrated the ability to distribute computation across military platforms 1-100 meters in length for future Electronic Warfare/digital radar and image processors.

- Distributed Robotics. ($ 13.000 Million)
  - Constructed the unit platforms, integrated commercial or demonstrated technology elements (e.g., imagers, MEMS, wireless systems), and defined multiple, cooperative functions for selected military applications.

- Composite CAD. ($ 15.763 Million)
  - Continued to develop the mixed domain software (kinematic, electric, electrostatic and fluidic) analysis of micro-machined devices, systems of devices and corresponding electronic circuits to support the design of composite electronic sensors and systems.

- Photonic A/D. ($ 9.000 Million)
  - Initiated photonic A/D converter development to achieve breakthrough in high speed A/D conversion.

- Molecular-level Large-area Printing (MLP). ($ 11.992 Million)
  - Completed experimental characterization of first generation printing processes.
  - Selected second generation printing process.

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(U) FY 2000 Plans:

- Photonic A/D. ($ 15.100 Million)
  - Evaluate alternative photonic clock, optical sampler and quantizer module designs for photonic A/D converters operating in the 10-100 Giga-sample-per-second range.
  - Identify high impact applications for this technology.
- Distributed Robotics. ($ 13.467 Million)
  - Demonstrate feasibility of a variety of multiple robots (<5cm) to operate in specific military environments and their ability to adapt to varying environments and missions.
  - Demonstrate probability of mission success improved by distributed functionality.
- Composite CAD. ($ 10.544 Million)
  - Complete the development of systems software design and simulation capabilities for mixed technology micro-systems, including MEMS-enabled designs and microfluidic (Micro-Flumes) designs. The ultimate goal of the complete systems design capability is to enable mixed technology systems-on-a-chip.
  - Provide mixed technology design libraries, models and test structure data to improve design quality, development time and ability to reuse designs.
- Molecular-level Large-area Printing (MLP). ($ 16.042 Million)
  - Concentrate on the development and choice of non-conventional large-area, MLP techniques for a demonstration system.
  - Establish overlay capabilities for MLP.

(U) FY 2001 Plans:

- Photonic A/D. ($ 16.178 Million)
  - Complete initial photonic A/D converter evaluation and finalize design for demonstration module.
  - Demonstrate key photonic technologies.

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- Distributed Robotics. ($ 14.678 Million)
  - Demonstrate multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.

- Molecular-level, Large-area Printing (MLP). ($ 12.828 Million)
  - Demonstrate and characterize 10,000 x 100 pixel density array on a spherical surface.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile :

Plan	Milestones
Mar 00	Evaluate initial PACT test and measurement methodology.
Apr 00	Characterize single crystal semiconductors on amorphous surfaces.
Jun 00	Establish overlay capabilities for MLP.
Jul 01	Demonstrate and characterize 10,000 x 100-pixel density array on spherical surface.
Aug 01	Demonstrate multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-05					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Tactical Information Systems MT-05	31.519	20.668	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This project will develop the technology for transmitting and displaying critical situational awareness and surveillance information to the warfighter. This project consists of Smart Modules, Warfighter Visualization and Ultra-Wideband Communications. Smart Modules will design, develop and integrate prototype modules using core technologies that communicate into personal information products. Warfighter Visualization efforts demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer-generated information. Together these systems will provide the mounted and dismounted warfighter with an unprecedented awareness in the most hostile environments.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Smart Modules. ($ 16.562 Million)
  - Demonstrated a novel capture device that incorporates signal and data processing in a 3-D package for use by individual soldiers. This miniature device, weighing only a few ounces, is able to capture an image and rapidly analyze movement or correlate images with all processing done on the focal plane. The camera is compact enough to be worn by individual soldiers and communicate via a radio to and from geographic information system databases.
  - Demonstrated a wearable computer incorporating wireless communication in a one pound, one-watt configuration. This represents a three-fold improvement in weight and a ten-fold improvement in power over current technology. The wearable computer will be used in a wide variety of space applications by the small unit operations soldier.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-05

- Warfighter Visualization. ($ 14.957 Million)
  - Demonstrated ability to do precision, real-time georegistration using video from the Predator unmanned aerial vehicle. This capability enables vastly enhanced situational awareness by obviating the "soda straw" effect of narrow field of view video. This technology development was rapidly accelerated and used to provide coordinates on mobile targets at the Combined Allied Operation Center in support of Operation Allied Force.
  - Demonstrated prototype capability for dismounted soldiers to view the real world with tactical symbology in a battlefield environment. This technology makes use of a novel optical tracking technology that uses novel compact image processing hardware to back compute the location of camera from points in the scene. This capability provides location information in urban environment where GPS is jammed or blocked.

(U) FY 2000 Plans:

- Warfighter Visualization. ($ 20.668 Million) [Future Combat Systems – related = $3.000 Million]
  - Demonstrate a high performance special purpose processor that will take the capabilities of real-time georegistration and precision targeting demonstrated in Vicenza, Italy and shrink them onto a single chip. This will shrink the system for vehicle mounting or ultimate portability by a dismounted soldier or in handheld units such as night vision goggles.
  - Demonstrate a prototype advanced human interface capability for use in conjunction with other bodyworn processing units. This system will combine "supernormal" listening with tactile inputs and displays for a dismounted soldier.
  - Demonstrate full-surround foveal vision system for glass turret. This system matches the human visual system by providing high resolution only where it is needed in the visual field, but provides a seamless image using advanced video processing system.
  - Develop change-detection technology to interpret reconnaissance imagery and enhance intelligence community capabilities.

(U) FY 2001 Plans:

- Not Applicable.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-05

(U) Schedule Profile:

Plan	Milestones
Warfighter Visualization:	
Jul 00	Develop real-time visual data correlation system in dismounted and mounted warrior applications.
Dec 00	Demonstrate dynamic multi-sensor I/O in both dismounted and mounted military applications.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Centers of Excellence MT-07	6.062	5.478	4.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Byrd Institute provides both a teaching factory and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training includes technologies to significantly reduce unit production and life cycle costs, and to improve product quality. This project also includes funding for the U.S.-Japan Management Training Program, whose purpose is to build a growing infrastructure of American scientists and engineers with knowledge about the Japanese R&D enterprise and provide training in the Japanese language, and has funded the Defense Techlink Rural Technology Transfer Project.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Advanced Flexible Manufacturing. ($ 3.618 Million)
  - Completed expansion of the Institute for Advanced Flexible Manufacturing's satellite facilities.

- U.S.-Japan Management Training. ($ 1.444 Million)
  - Completed efforts with centers of excellence to support the understanding of Japan's manufacturing infrastructure, culture and language by students, researchers and executives.

- Defense Techlink Rural Technology Transfer Project. ($ 1.000 Million)
  - Provided funding for the Defense Techlink Rural Technology Transfer Project.

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(U) FY 2000 Plans:

- Advanced Flexible Manufacturing. ($ 3.978 Million)
  - Expand the Institute for Advanced Flexible Manufacturing's web-based electronics supply chain support to include 150 small manufacturers who now have access to Defense on-line procurement activities.

- Defense Techlink Rural Technology Transfer Project. ($ 1.500 Million)
  - Provide funding for the Defense Techlink Rural Technology Transfer Project.

(U) FY 2001 Plans:

- Advanced Flexible Manufacturing. ($ 4.000 Million)
  - Complete assessment of the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Oct 01	Complete assessment and transition of the Institute from DoD to state/private support.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-08					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Manufacturing Technology Applications MT-08	20.685	18.564	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) Future military systems will be affordable only if the manufacturing process is considered as an integral part of product design, production takes place in flexible multi-product factories, and if advanced manufacturing technology is combined effectively with advanced business practices. This program focuses on demonstrations of process technology combined with innovative industrial practices and will measure the improvements in cost, schedule and quality achievable in key defense product areas.

(U) The Affordable Multi-Missile Manufacturing (AM3) program is an Advanced Technology Demonstration initiated in FY 1995. The objective of AM3 is to demonstrate the feasibility of 25-50 percent reductions in the unit cost of tactical missiles, in ongoing missile production programs, in new missiles and major modifications. This will be accomplished by teams of missile prime contractors, component suppliers and manufacturing equipment and software vendors who develop and demonstrate the combined effects of advanced design, manufacturing, assembly systems and processes, missile value engineering changes, and acquisition reform and business practice innovations. A major technical theme is to achieve economies across a mix of missiles to compensate for the decline in individual missile quantities. Demonstrations will be conducted in the design and manufacture of components and guidance and control/seeker assemblies for multiple missiles, including R&D and production programs.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Affordable Multi-Missile Manufacturing (AM3). ($ 20.685 Million)
  - Established Technology Product Centers in key design product areas that use modular reusable design and standard parts concepts.
  - Established multi-product factory and multi-missile factory utilizing multi-missile factory concepts.
  - Continued progress with key suppliers on sourcing strategies, working toward completion of a supplier affordability process.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-08

- Completed design phases of reusable hardware demonstration projects – involving Inertial Measurement Unit (IMU), common processor and common infrared test station – and began validation and insertion.
- Continued rapid product development and producibility demonstrations on brilliant anit-tank, joint standoff weapon, standard missle-2, extended range guided munitions, and experimental munition-982 toward eventual completion and deployment in FY 2000.
- Successfully completed Activity Based Management demonstration at Ocala facility.
- Completed training for missile suppliers AM3 programs and awarded contracts for affordability initiative demonstrations.
- Completed planning and simulation for multi-missile factory demonstration, gaining approval to proceed with implementation.
- Continued progress with common family of parts demonstrations, awarding contracts for common IMU and progressing in other MEMS and IFOG/RLG efforts.
- Completed installation of Integrated Enterprise Resource Planning software, now operational.
- Continued progress in rapid product design environment – new design tools, now operational.
- Completed validation and definition for use of commercial electronic parts in missile applications.

(U) FY 2000 Plans:

- Affordable Multi-Missile Manufacturing (AM3). ($ 18.564 Million)
  - Complete integration of flexible factory assembly areas.
  - Deploy System Integration Design Environment.
  - Complete design and prototype fabrication of low cost IMU.
  - Complete common processor design verification test and integration.
  - Validate electronic collaborative tools and complete supplier affordability demonstration.
  - Complete integration of guided flight unit, gyro optics assembly fabrication and mid-body casting demonstration.
  - Complete common seeker commercial parts test evaluation, producibility analysis and flight test.
  - Complete common IMU design verification test, prototype demonstration unit and technology insertion review.
  - Complete process design for flexible multi-product assembly cells, validate on production parts and demonstrate on production line.
  - Complete electronic procurement and supplier integration demonstrations.
  - Design, build, and test laboratory and ground vehicle-mounted prototypes of a GPS Missile Retargeting Pseudolite.

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(U) FY 2001 Plans:

- Not Applicable.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Mar 00	Complete common processor design verification test and integration.
Mar 00	Complete process design for flexible multi-product assembly cells, validate on production parts and demonstrate on production line.
Jun 00	Complete flight tests of AM3 missile seeker prototypes.
Jul 00	Demonstrate a Laboratory Prototype of a GPS Missile Retargeting Pseudolite.
Jul 00	Complete integration of guided flight unit, gyro optics assembly fabrication and mid-body casting demonstrations.
Jul 00	Complete electronic procurement and supplier integration demonstrations.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Lithography MT-10	48.026	44.791	45.012	45.013	45.000	44.000	45.000	Continuing	Continuing

(U) Mission Description:

(U) Microelectronics is a key to improved weapon system performance. Lithography technology has enabled the dramatic growth in microelectronics capability over the past three decades. The improved capabilities in semiconductor technology contribute to significant system gains in speed, reliability, cost, power consumption and weight. Advanced microelectronics technology is essential for computing and signal processing in virtually all military systems including command, control, communications and intelligence; electronic warfare; and beam forming for radar and sonar. Further improvements in areas such as target recognition, autonomous guided missiles and digital battlefield applications require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints of these systems.

(U) Current microelectronics fabrication utilizes feature sizes of 0.35 microns. The Advanced Lithography Program emphasizes longer-term research with expected high payoff in the fabrication of semiconductor devices with 0.1 or less micron feature sizes. These programs will develop technology for sub 0.1-micron features.

(U) The goal of the lithography program is to reduce technical barriers in the development of advanced lithographic technologies for the fabrication of a broad range of microelectronic devices and structures. Innovative research in pattern generation and transfer, imaging materials, new process and metrology will provide alternatives beyond current evolutionary trends. The program will investigate technologies for the creation of highly-complex patterns at sub 0.10μm resolution over field areas in excess of 1000 mm^2. Applications with larger geometries will be explored for innovative devices and structures beyond microelectronics.

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(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Sub 0.1 Micron Technology. ($ 24.887 Million)
  - Continued efforts in maskless lithography, including arrays of miniature e-beam columns, novel imaging materials and pattern transfer processes.
  - Continued network of university efforts in novel patterning.
  - Completed column test stand for maskless e-beam writer.
- Laser Plasma X-ray Source. ($ 5.951 Million)
  - Continued laser plasma x-ray source technology.
- X-ray Masks. ($ 13.888 Million)
  - Continued x-ray mask writer development.
  - Developed x-ray masks for the F-22, Apache Longbow and other defense programs.
- Nanotechnology and Crystalline Arrays. ($ 3.300 Million)
  - Initiated research in nanotechnology and crystalline control arrays.

(U) FY 2000 Plans:

- Sub 0.1 Micron Lithographies. ($ 22.791 Million)
  - Develop key tool components, materials and processing to accelerate the availability of emerging lithography technologies beyond 193 nm. Efforts will include maskless (electron beam, ion beam) approaches and the projection technologies, using optical, electron, x-rays and extreme ultraviolet.

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- Support Technologies. ($ 16.000 Million)
  - Develop support technologies, to include mask technology, resists and metrology.
  - Develop innovative optics designs and architectures and new materials and processing beyond the evolutionary trends in the industry.

- Laser Plasma X-ray Source. ($ 5.000 Million)
  - Continue laser plasma x-ray source technology.

- Point Source Lithography ($ 1.000 Million)
  - Continue point source lithography development.

(U) FY 2001 Plans:

- Sub 0.1 Micron Lithographies. ($ 25.900 Million)
  - Demonstrate key components of maskless wafer writer and key components for lithography of 0.07 micron features.

- Support Technologies. ($ 19.112 Million)
  - Accelerate technology developments in the lithography exposure sources and supporting (cross-cutting) technologies needed for microelectronics fabrication.
  - Develop reduced risks in key areas of components, materials and processing allowing industry to fabricate prototype tools and new high-performance devices for use in advanced military systems and commercial markets.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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(U) Schedule Profile:

Plan	Milestones
Jul 00	Demonstrate ion microcolumn for maskless lithography.
Mar 01	Component demonstration of maskless wafer writer.
Aug 02	Demonstrate key components for lithography of 0.07-micron features.
Sep 02	Demonstrate key components for mask writer for sub 0.1-micron features.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project Technology MT-12					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
MEMS and Integrated Micro-systems Technology MT-12	75.955	74.711	37.712	37.590	24.000	24.025	10.825	Continuing	Continuing

(U) Mission Description:

(U) The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to develop an enabling technology that merges computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS provides the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. The microfluidic molecular systems program will develop automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences to monitor environmental conditions, health hazards and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

(U) Compact portable power sources capable of generating power in the range of a few hundred milliwatts to one watt are critical to providing power for untethered sensors and other chip-scale microsystems. This program aims to replace today's technologies relying on primary and rechargeable batteries, which severely limit mission endurance and capabilities, by extending microelectronic machine technology to develop micro-

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power genrators based on mechanical actuation and thermal-electric power generation. Operating with traditional fuels, these micro-power generators will be capable of generating sustained power in the desired range for use with remote, field-deployed microsensors and microactuators.

(U) Within this project is the development of totally integrated microfluidic chips to enable ubiquitous yet unobtrusive assessment of the warfighter's body fluids. These microchips integrate detection, diagnostics and treatment in one chip-scale system called Bio-Fluidic chips.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- MEMS Devices and Processes. ($ 17.344 Million)
  - Demonstrated radio frequency electromechanical signal processing; MEMS-based mass data storage; massively parallel read/write structures; micro thrusters for satellite attitude, propulsion and control.

- MEMS System Design and Development. ($ 20.379 Million)
  - Initiated concept demonstrations for systems in the form of aerodynamic control of model aircraft; low-power wireless integrated microsensor for structural health, maintenance and monitoring; gas-phase microinstruments; polymer-based MEMS; and micro power sources.
  - Demonstrated a MEMS miniaturized fuze/safety and arming device for use in small diameter submarine torpedo counter weapons.

- MEMS Support and Access Technology. ($ 19.132 Million)
  - Integrated development in robotics and ultra-miniaturized electronics to design, construct and field mutiple, high performance, mobile, autonomous systems.

- CAMD. ($ 3.863 Million)
  - Continued micro device manufacturing processes at the Center for Advanced Microstructures and Devices (CAMD).

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project Technology MT-12

- Microfluidics. ($ 15.237 Million)
  - Demonstrated a microfluidic sensor system capable of indicating specific DNA hybridization events.
  - Demonstrated detection of pathogens or protein molecules without requiring reporters by using coated beads and DEP/FFF/IS (dioelectrophoresis-field flow fractionation-impedance sensor).
  - Demonstrated prototype microfluidic system to reconstitute a 20-ml volume of lyophilized material in one minute to five-percent reconstitution accuracy using thermocapillary pumping and mixing.
  - Demonstrated automated isothermal DNA analyzer: multichannel, microchip device with integrated aerosol collector.
  - Demonstrated portable biodetector prototype with sensitivity for three types each of bacteria, viruses and toxins as well as sensitivity to unknown toxicants by cell or coated beads.

(U) FY 2000 Plans:

- MEMS Devices and Processes. ($ 20.500 Million)
  - Develop new devices and processes that survive extremely harsh environments and facilitate the integration of micro-mechanical as well as micro-chemical systems into electronic circuits. These new devices include micro power sources, mechanical-microprocessor units, micro actuators, communication components, MEMS aerodynamic pressure sensors on flexible adhesive tape substrate; modular, monolithically integrated MEMS Inertial Measuring Unit (IMU); and MEMS high-temperature sensor and actuator arrays.
  - Demonstrate micro devices that will reduce communication equipment to the size of a credit card; optimize the aerodynamics of an airplane wing for lift and drag; provide intelligence to machine components to allow them to report their condition and state of readiness (e.g., “smart wheel bearings”); and increase the resistance of jamming of GPS used on smart munitions.
  - Integrate power sources with the MEMS devices and expand the use of MEMS in fluidic applications.

- MEMS System Design and Development Phase II. ($ 16.211 Million)
  - Initiate technology demonstrations relevant to micro airborne sensor/communicator platforms and chemically powered remote sensors; subsystems for PicoSatellites; electromechanical signal processing; and nanoelectromechanical systems.

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- CAMD. ($ 4.000 Million)
  - Continue microdevice manufacturing processes at the Center for Advanced Microstructures and Devices (CAMD).

- MEMS MicroPower Generation. ($ 25.000 Million)
  - Demonstrate feasibility and practical limits of converting chemical energy into electrical energy on the micro-scale using MEMS technology. The goal is to replace primary and rechargeable batteries with micro power generators that have at least one order of magnitude higher energy density, and thus drastically reducing weight and volume of power sources.
  - Develop high-energy density power generation on micro-scale from fuels.
  - Develop stand alone, remotely distributed MEMS sensor networks.

- Bio-Fluidic Chips (BioFlips). ($ 9.000 Million)
  - Design microscale fluidics integrated with optical and/or electronic detection to monitor cellular activities of body fluids.
  - Design chip interface with bio-fluids for continuous sampling and fluids delivery.
  - Develop on-chip reagent storage and reconstitution.

(U) **FY 2001 Plans:**

- MEMS Micro Power Generation . ($ 19.844 Million)
  - Demonstrate chip-level integration of components for fuel processing, thermal management, energy conversion and exhaust management for micro power generation. Enable stand alone, remotely distributed micro sensors with built-in power supply and RF communication in addition to various sensing functions.
  - Develop MEMS free-piston knock engine.
  - Develop an integrated fuel cell and fuel processor for microscale power generation from liquid fuels.
  - Develop integrated chemical fuel microprocessor for power generation in MEMS applications.
  - Develop 3-D monolithically-fabricated thermoelectric microgenerator.

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- Bio-Fluidic Chips (BioFlips). ($ 17.868 Million)
  - Develop closed-loop bio-fluidic chips to regulate cellular transduction pathways and precise dosage of chemicals/drugs/ reagents/enzymes.
  - Fabricate and test individual microfluidic chip components and integrated sensors for flow control.
  - Manipulate (pump/valve/sense) bio-fluids in integrable microfluid components.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Mar 00	Demonstrate electromechanical signal processing.
May 00	Demonstrate MEMS aerodynamic pressure sensors on flexible, polyamide belt.
Jun 00	Demonstrate modular, monolithically integrated MEMS Inertial Measurement Unit (IMU).
Aug 00	Demonstrate subsonic roll, pitch and yaw control via MEMS.
Sep 01	Demonstrate atomic resolution data storage.
Aug 02	Demonstrate MEMS micro combustion.
Feb 03	Demonstrate MEMS heat engines.
Sep 03	Demonstrate MEMS electrical power generation.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Mixed Technology Integration MT-15	0.000	22.291	49.476	52.959	56.800	57.300	57.300	Continuing	Continuing

(U) Mission Description:

(U) The goal of the Mixed-Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems that will revolutionize the way individuals see, hear, taste, smell, touch and control their environment at-a-distance, a paradigm that addresses many of the present and future needs of the DoD. These 'wrist watch-size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: Microelectromechanical Systems (MEMS), microphotonics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) Microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies. This new paradigm will create a new class of 'match-book-size', highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microsensors, microrobots and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions and UAVs.

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using 'standard' processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and 'multiple-chip-scale' packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotonics, microelectronics and

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microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume and cost of weapon systems while increasing their performance and reliability.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

(U) FY 2000 Plans:

- Three-D Imaging Devices. ($ 7.310 Million)
  - Initiate program to develop new high speed imaging device technology to rapidly acquire a high-resolution 3-D image of a tactical target at ranges of 7-10 kilometers increasing identification range of tactical targets, especially from fast moving platforms.
  - Develop near infrared materials with point defect density less than 1000/sq cm.
  - Demonstrate 4x4 array of detectors with gain of 30 at 1GHz.
  - Complete investigation of novel high gain detector concept.

- Steered Agile Laser Beams. ($ 6.830 Million)
  - Initiate program to develop compact, lightweight, man-portable, electronically steered lasers to replace large, heavy gimbal mounted lasers in lasercom links and smart weapon target designators.
  - Develop small, lightweight laser beam scanner system technologies for replacement of gimbaled mirror systems.
  - Initiate system design and component specifications; select system design.

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- RF Lightwave Integrated Circuits (R-FLICS). ($ 8.151 Million)
  - Initiate program to demonstrate, with heterogeneous integration, lightwave and RF technologies to route, control and process analog RF Signals in the 0.5-50 GHz range.
  - Develop RF-Photonic modules to enable links with better than zero net RF loss from input to output.
  - Develop and demonstrate optically integrated modules capable of performing complex RF functions such as signal channelization or single chip generation of multiple RF signals.

(U) FY 2001 Plans:

- Three-D Imaging Devices. ($ 16.825 Million)
  - Complete design of high-speed electronics for sub-nanosecond detection.
  - Integrate high-speed electronics with 5x5-detector array and integrate into brass board imaging system.
  - Demonstrate laboratory imaging with 5x5 array.
  - Select detector design for 128x128 3-D imaging array.

- Steered Agile Laser Beams. ($ 17.825 Million)
  - Develop electronically steered laser beam technology for use in covert, anti-jam, high bandwidth battlefield communications - hand held ground-to-ground recon units, which are able to transmit images and geo-location data of targets, and for use in target designators for small unit operations in high threat environments.
  - Fabricate beam steering emitters and detectors.

- RF Lightwave Integrated Circuits (R-FLICS). ($ 14.826 Million)
  - Focus program on identified key applications for integrated RF-Photonic modules and produce initial prototypes and demonstrate methods for evaluation of their performance.
  - Initiate parallel efforts to develop components for efficient RF links exhibiting better than zero net loss and to demonstrate the advantages of integrated optical-RF modules for RF systems.
  - Down select among technology options and develop prototype module for demonstration.

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(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
3-D Imaging:	
May 00	Develop low defect density near infrared materials suitable for high speed imaging.
Aug 00	Demonstrate detector test arrays with gain/bandwidth product capable of sub-nanosecond detection at long range.
Feb 01	Integrate novel, high gain/bandwidth detector array with low noise electronics.
Steered Agile Laser Beams:	
Feb 00	Select system configuration that best meets insertion target performance goals.
May 00	Derive component specifications.
Aug 01	Fabricate beam steering emitters and detectors.
R-FLICS:	
Feb 01	Demonstrate High Performance R-FLIC Components to 50 GHz bandwidth.
Aug 01	Demonstrate integrated R-FLIC functions such as channelizer with 10 GHz selectivity over 0-50 GHz bandwidth.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, R-1 #44					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	171.370	185.926	128.863	130.688	136.480	144.046	153.071	Continuing	Continuing
Command & Control Information Systems CCC-01	82.299	100.583	79.209	92.557	104.234	109.534	117.234	Continuing	Continuing
Information Integration Systems CCC-02	89.071	85.343	49.654	38.131	32.246	34.512	35.837	Continuing	Continuing

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The Command and Control Information Systems project is developing the technologies necessary to facilitate joint campaign planning and control throughout the battlespace. The primary program in this project is the Joint Forces Air Component Command System (JFACC), which will revolutionize command and control of joint and coalition air forces through the incremental development, integration, evaluation, demonstration, and transition of technology and systems. Other programs addressed in this project include: the Dynamic Command and Control Systems program; the Information Assurance Science and Engineering Tools; the Advanced Intelligence, Surveillance and Reconnaissance (ISR) Management (AIM) program; the Agent-Based Systems program; Project Genoa; and the Active Templates program.

(U) The Information Integration Systems project will develop the technologies necessary to ensure that the enhanced information required by battlefield combatants is available on a near real time basis. Programs addressed in this project include: the Agile Information Control Environment (AICE) program; the Dynamic Database (DDB) program; the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD); the Airborne Communications Node (ACN) program; and the Command Post of the Future program.

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

	FY1999	**FY 2000**	**FY 2001**
Previous President's Budget	177.492	222.888	213.380
Current Budget	171.370	185.926	128.863

(U) **Change Summary Explanation:**

FY 1999	Decrease reflects restructuring of the Joint Forces Air Component Command System (JFACC) and Dynamic Database (DDB) programs; termination of the Dynamic-Multi-User Information Fusion (DMIF) program and SBIR reprogramming.
FY 2000	Decrease reflects congressional reductions, a government wide rescission, inflation reductions and minor program repricing.
FY 2001	Decrease reflects the restructuring of JFACC and DDB programs and accelerated completion of the AICE program. In addition, the decrease is due to consolidation of portions of the Information Assurance programs in PE0602301E, project ST-24, with application-oriented developments remaining in project CCC-01.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Command Control Information Systems CCC-01	82.299	100.583	79.209	92.557	104.234	109.534	117.234	Continuing	Continuing

(U) Mission Description:

(U) Military operations that have taken place since the end of the cold war have demonstrated that current theater command, control, communications, intelligence/information systems, and planning and rehearsal systems lack the ability to fully support operations in diverse new environments and scenarios. These range from conflict and peacekeeping in urban areas with large civilian populations to heavy battle actions in remote areas. Current capabilities do not provide the Commander with real time, secure, situational awareness, nor the ability to conduct decentralized planning, rehearsal and execution. Additionally, the present systems do not provide flexible interfaces or critical interoperable assured communications. The goals of the programs in this project are to build on an innovative architecture and secure infrastructure to enhance information processing, dissemination and presentation capabilities for the Commander. This will be done by including information pertaining to the disposition of enemy and friendly forces, providing a joint situational awareness picture, and improving planning, decision-making and execution support capability, and providing secure multimedia information interfaces and assured software to "on the move users". Integration of collection management, planning and battlefield awareness programs is an essential element of our strategy for achieving battlefield dominance through assured information systems.

(U) The Joint Force Air Component Commander (JFACC) Project seeks to catalyze a revolution in military command and control (C2), specifically joint and coalition air operations. The objective of the program is to develop innovative technologies that will enable agile and stable control of distributed military operations conducted in an uncertain and rapidly changing environment, dramatically enhancing the effectiveness and efficiency of the Joint Force Air Component Commander. Based on lessons learned from earlier efforts within the program, it was noted that as observation, orientation, decision, and execution times are driven toward progressively shorter timelines, the control of dynamic phenomena within real-time operations becomes the key challenge to practical implementation of any new generation of C2 systems. The emphasis for this program has therefore shifted toward the entire air operations enterprise, expanding and understanding the theories, models, technologies, architectures and concepts that can manage the dynamic effects of large scale, highly agile command and control systems. JFACC will develop and validate new C2 architectural concepts and appropriate control strategies with the ability to: (1) rapidly and efficiently respond to varying objectives and guidance, time constraints, changeable resources, erratic hostile responses, asymmetric threats and unpredictable anomalies (Agility); (2) proactively manage destabilizing events, such as time critical targets, while simultaneously avoiding undesirable long-and short-term effects, to include disruptive and

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inefficient impacts on downstream plans and operations (Stability); (3) adapt to the wide spectrum of military conflicts and activities (Flexibility); (4) provide feedback with reliable performance assessments at the level of abstraction and integration that allows decision makers to make effective decisions (Visibility); and (5) drastically reduce the required number of personnel and physical facility footprints for each C2 node (Cost and Vulnerability). This extension and application of theoretical techniques and tools for the analysis, synthesis, and execution of real-time dynamic control includes these unique technical challenges: (1) a hybrid of symbolic and continuous control and feedback signals (representation of operations); (2) control of nested, dynamically changing execution elements (structural and spatial changes in engaged and supporting forces); (3) predictive, reflexive, and generative state estimation with input and feedback signal ambiguities (decisions and assessments with uncertain and incomplete information); (4) hybrid and distributed control system architectures (centralized, de-centralized, self-organizing, etc.); (5) system control with dynamic counteracting disturbance signals (an active adversary); and (6) complementary human and machine control signals (mixed human/machine decisions).

(U) Current military command and control (C2) systems, concepts, and architectures employ a decision cycle (e.g. observe, orient, decide, and act) which is analogous to closed loop feedback Control Theory. Recent experimental discoveries in the DARPA Joint Force Air Component Commander (JFACC) program have verified the efficacy of using the mathematics and science of Control Theory in a dynamic military C2 architecture. The Dynamic Command and Control (DC2) program will produce selected prototype tools that will validate the application of these recent discoveries and advances in Control Theory within a representative military operational environment. The DC2 program will develop an option-rich decision environment with a greater understanding and representation of the predicted outcomes and potential rolldown effects - making for a more responsive and agile C2 system. The DC2 program will support change management to ensure that fluctuations are appropriately minimized and uncertainty is treated as an explicit decision variable - making for a more robust and stable military operation. The DC2 program will enable faster-than-human response to a wide variety of situations, to include time-critical targets, feedback synthesis, change recognition, and other potentially automated military actions - complementing human decision-makers. The DC2 Program will provide the warfighter with the technological catalyst for a revolution in military command and control.

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services -- particularly in a stressed environment. Information Assurance (IA) technologies will be integrated into future versions of the Defense Information Infrastructure (DII) to provide a robust architecture across a wide range of DoD information systems. The development and fielding of secure information systems will be a continuing process of development and upgrading of existing systems and capabilities. The program is developing and refining information security technology into DII architectures and testbeds. As part of the program, the IA project is beginning to build a science and engineering discipline base for information assurance. One hypothesis to be tested is whether it is possible to create trustworthy systems from innovative

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integration of relatively untrustworthy mechanisms. The resulting security framework will reduce information vulnerability, allow increased interoperability and functionality, and provide the operational commander greater assurance that he will have the information he needs when he needs it. The initial investment provides near term applications to provide a modest level of protection, and a mechanism to test advanced secure information development in an end-to-end environment.

(U) A new generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision-maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation, and dissemination capabilities to provide the critical information to the decision-maker in the constantly changing operational situation. The Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) program will expand on efforts begun under the Joint Force Air Component Commander (JFACC) program and provide the technical foundation for ISR support to Joint Vision 2010 and beyond through the development of Information Needs Generation, Collection Strategy Development, and Multi-Asset Synchronization capabilities to dynamically optimize/synchronize, schedule, and request spaceborne, as well as task organically controlled airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM program will optimize ISR support to precision engagement and dominant maneuver by providing proactive information support to the warfighter, continuous integration of Operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking. AIM's Information Needs Generator effort will ensure near-real-time (NRT) information support to component commanders and the Joint Task Force (JTF) by providing all echelons with: a common view of the collection environment; current status of collection, processing, exploitation, and dissemination operations; faster than real-time simulations in support of trade-off decisions; and the ability to conduct real-time multi-echelon coordination and shared decision making. AIM's Collection Strategy Development effort will interoperate with future automated operational plan representations to continuously interpret ISR requirements contained in the plan and decompose these requirements into discrete sensor, information retrieval, and exploitation tasks. AIM's Multi-Asset Synchronization effort will simultaneously plan and integrate platform routes and schedules that maximize the total information value from the ISR confederation in support of the operational plan. The AIM program will develop or advance technologies in the following areas: multi-node collaboration, semi-automated reasoning, mathematical programming, and cognitive representations. Resulting AIM capabilities will transition to DoD automated planning and C4ISR migration systems as appropriate. Developed capabilities from the AIM project will be installed and operated at the United States Southern Command to ensure the utility of the technologies.

(U) The Control of Agent-Based Systems program will develop scaleable control strategies that enable intelligent software assistants for warfighters allowing them to delegate tasks such as information gathering, logistics supply, and operations planning that can be automated, but currently overload military personnel. Unlike other software, agents reduce the user's workload by operating autonomously and using available information to make intelligent decisions on behalf of the user. Agents are cost-effective; adaptive to new users, tasks, and computing

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environments; and collaborate with other agents on the network to solve problems. Agents also support a new lightweight approach for connecting dissimilar applications that don't speak the same language, but could be dramatically more powerful by sharing data and algorithms. The Control of Agent-Based Systems program will develop control strategies and an interoperability tool to ensure heterogeneous agent systems work correctly and predictably in the evolving Defense Information Infrastructure. This tool will be employed as a basis for agentization of military legacy systems.

(U) Project Genoa is developing tools and a prototype infrastructure for collaborative crisis understanding and management for the national security community ranging from the National Command Authorities to Commanders of the Unified Commands. The growing transnational threats increase the need for early crisis discovery and mitigation. The earlier a crisis situation is discovered, identified and understood at the National Command Authority level, the easier it is to arrive at preemptive or mitigating strategies. The objectives are to: (1) decrease decision cycle time from days to hours by reducing the time it takes to go from detection of a problem to completion of a thorough briefing with actionable options for the decision maker; (2) increase number of situations that can be managed simultaneously by an order of magnitude because with the increasing number of potential crisis situations and reduced resources we must make analysts more efficient, cover more situations and provide more diverse options; and (3) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from unstructured multimedia sources; structured argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory which will enable comparison of critical information across situation, time, and organization. Genoa will use technologies from other DARPA programs such as Information Assurance as well as commercial technologies. The current clients for components of the prototype system are Commander in Chief Pacific (CINCPAC) and Defense Intelligence Agency (DIA).

(U) The Active Templates (AcT) program will produce a robust, lightweight software technology for aiding in the automation of detailed planning and execution for military operations using a plan spreadsheet metaphor. Active Templates are distributed data structures whose variables will be linked to live data feeds or problem-solving methods. Active Templates will assist with automated planning and execution by capturing, improving and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context, and rationale. Active Templates will be designed to be user-tailorable, networked, noise-tolerant, user-supported, scalable, and widely adopted. As a result, the technology to be fielded will provide faster plan generation (6 times), improved plan quality (8 times more options considered), 60 percent reduction in staff-hours required to track and coordinate missions, enhanced ability to capture lessons learned, and improved national capability to respond in a crisis.

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(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Joint Force Air Component Commander (JFACC). ($ 27.403 Million)
  - Evaluated JFACC program results to date and lessons learned. Identified the critical need for new enterprise control techniques to provide system agility, stability, and responsiveness required for dynamic, real-time military operations.
  - Restructured the program focusing on the agile and stable control of military operations. Established a new JFACC Team of performers in line with program restructuring.
  - Established an experimentation laboratory.
  - Developed object-based semantics for distributed operations and demonstrated its utility via a set of interoperability experiments.
  - Transitioned several JFACC-developed technologies into Service weapons systems and commercial markets.

- Information Assurance. ($ 20.818 Million)
  - Demonstrated automated capabilities to limit system access, protect data, manage replication and recovery, provided advanced detection and response to intrusions, anti-flooding techniques, and reconstituted/reconfigured information services to reflect dynamic operational priorities.
  - Demonstrated capability to do integrated monitoring of network service data, detected intrusion status and configuration/ reconfiguration; managed allocation of components and resources dynamically to reconstitute critical functions that have been degraded.

- Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 9.550 Million)
  - Developed AIM tools for information management, strategy development, and multi-asset synchronization.
  - Conducted data collections at Special Project '99 to support technology development.
  - Evaluated ISR, logistics, and operations planning in an integrated experimental demonstration with the JFACC and ALP programs.

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- Control of Agent-Based Systems. ($ 13.365 Million)
  - Developed a framework to facilitate the integration, interoperability, and collaboration of heterogeneous systems between agents, object-based services and applications, and devices to assist information gathering and enhance military planning capabilities.

- Project Genoa. ($ 11.163 Million)
  - Project Genoa began user evaluation of selected components to establish performance metrics relevant to crisis situations. These experiments included initial knowledge discovery, structured argumentation, and argument presentation tools.
  - Components of the prototype system were installed at the DARPA test site for remote access by CINCPAC, DIA and other national security components for these user experiments and evaluations.
  - Developed engineering infrastructure to access user process data and conducted time and motion studies to identify baseline performance for special operations command and control activities.

(U) **FY 2000 Plans:**

- Joint Force Air Component Commander (JFACC). ($ 21.569 Million)
  - Develop a reconfigurable model that simulates the dynamic phenomena within the military air operations enterprise. Using the enterprise model, identify the dynamic behaviors within military air operations, which must be stabilized by the application of innovative control strategies.
  - Experimentally investigate the stability effects of new control technologies and C2 architectures incorporated within the air operations enterprise model.
  - Validate the feasibility of a 10-fold reduction in the time to initiate a required change in operations, with accurate understanding of side and downstream effects.

- Information Assurance. ($ 36.569 Million)
  - Demonstrate automated capabilities that enable dynamic, secure collaboration between enclaves including data and invocation flow rules.

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- Demonstrate real-time, finer-grained advanced attack detection and response at the application layer, operating system, and network infrastructure. Couple advanced attack detection capabilities with automated system security and administration tools to enhance integrated monitoring and control of network services, detected attack status, and system configuration.
- Dynamically and automatically manage allocation of components and resources to reconstitute critical functions that have been degraded.
- Demonstrate security policy interoperability between enclaves. Explore knowledge base approach to adaptive systems management. Improve assurance measurement and risk analysis by establishing value functions for user data.
- Enhance object assurance granularity by augmenting Common Object Request Broker Architecture Security (CORBASEC).
- Complete selection of basic Information Assurance Science and Engineering Tools (IASET) architecture for incorporation into an integrated design environment.
- Conduct initial IASET experiments with information assurance design methodologies emphasizing the application of science-based metrics in assessment activities.

• Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 7.254 Million)
- Demonstrate dynamic replanning capabilities within an integrated collection management demonstration.
- Develop collection, exploitation, and dissemination synchronization techniques to link all phases of ISR management in support of the warfighter.
- Transition initial automated collection strategy tools to the Integrated Collection Management efforts in the Defense Intelligence Agency and the Joint Staff.

• Control of Agent-based Systems. ($ 15.730 Million)
- Develop and demonstrate a flexible information infrastructure and an interoperability tool called the Agent Grid, which will support the dynamic deployment of complex applications for dynamic domains such as military command and control.
- Demonstrate access to shared protocols and ontologies, mechanisms for describing agents' capabilities and needs, and services that support interoperability among agents at flexible levels of semantics distributed across a network infrastructure.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

- Project Genoa. ($ 11.692 Million)
  - Knowledge Discovery: develop and implement information extraction from text and extensive use of innovative visualization of complex information relationships.
  - Structured Argumentation: refine crisis models, develop tools for scenario based, alternative futures reasoning, and develop collaborative option generation, continue work on meeting transcription and develop ability to navigate and play back corporate memory.
  - Implement products from Information Assurance project so that a multi-intranet system may operate at mixed security levels. Continue evaluation by users from the national security community.

- Active Templates. ($ 7.769 Million)
  - Develop and encode templates of standard operating procedure, which integrate causal model capability to show how constraints, event triggering, inference, and uncertain reasoning can be utilized for fast crisis planning and execution.
  - Create a flexible networked architecture that supports template linking, dynamic connections, consistency management, and dynamic information sharing and characterize performance in terms of connection speed, message throughput, and consistency maintenance.

(U) FY 2001 Plans:

- Joint Force Air Component Commander (JFACC). ($ 5.000 Million)
  - Validate the feasibility of a 10-fold reduction in the disruptive side effects and downstream effects due to a required operational change (in addition to previous reductions in decision cycle time) through further development of dynamic control technologies and C2 architectures, and experimentation using the air operations enterprise model.
  - Initiate development of selected component prototypes to experimentally validate the viability of the new concepts and strategies.

- Dynamic Command & Control Systems. ($ 13.251 Million)
  - Construct a dynamic, multi-faceted architectural design for military command and control systems, which provides agility and stability to military operations.
  - Design system and selected component specifications based on the control theory discoveries which enable robustness and flexibility.
  - Develop an extensive library of operational "plant" models which can support a wide range of theoretical to operational experiments.
  - Experimentally validate the command and control architectures and design concepts produced during this phase.

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- Continue to explore new and innovative theories, techniques, and tools for agile and stable military operations.

- Information Assurance Science and Engineering Tools. ($ 21.696 Million)
  - Develop science-based security-enabling technologies, methods, and tools that will allow for the design of measurable and useful Information Assurance systems.
  - Conduct a series of mini-experiments to foster the initial incorporation of developments in Information Assurance sciences, mathematics, metrics, and science-based methods into a set of design and assessment tools.
  - Use experiment results to strengthen the development of the basic architecture into an integrated environment for the design and assessment of Information Assurance.

- Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 9.514 Million)
  - Explore new ISR system architectures and technologies to increase effectiveness and reduce manloading.
  - Conduct operational evaluation of AIM automated collection strategy development and multi-asset synchronization technologies with US Southern Command and in coordination with Joint Forces Command.
  - Transition multi-asset synchronization and automated collection strategy development tools to Army, Air Force, and Intel C^4ISR systems.

- Control of Agent-based Systems (CoABS). ($ 12.800 Million)
  - Demonstrate agent technologies and tools in a military scenario that enables the run-time integration and interoperability of software components such as legacy applications, objects, and agents – into applications customized to target present and future command and control problems.
  - Commence transitioning of CoABS developed technologies and tools for specific integration into Agent Markup Language and Taskable Agent Software Kit programs.

- Active Templates. ($ 10.000 Million)
  - Integrate and demonstrate multiple template merging by users to update information, add dependencies, and attach problem-solvers.

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- Project Genoa. ($ 6.948 Million)
  - Develop and validate emerging concepts from collective reasoning applied to the asymmetric threat. Investigate the use of intelligent agents to automate functions where possible.
  - Demonstrate products that will permit operations in a multi-level security environment. Incorporate changes resulting from client evaluation in real world asymmetric environment.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Mar 00	Framework for the JFACC air operations enterprise model established as the baseline for experimentation and evaluation of new control technologies and C2 architectural concepts.
Jun 00	Demonstrate collaboration in multi-agent systems developed without hard-coded interfaces.
Jun 00	Based on initial JFACC experiments using the air operations enterprise model, assess the contribution of theoretical techniques and tools toward control of air operations, including response times and level of understanding of enterprise dynamics.
Jul 00	Demonstrate modular combined arms execution toolkit and small unit synchronizing toolkit.
Jul 00	Demonstrate Knowledge Base approach to systems management.
Jul 00	Demonstrate user data value functions.
Jul 00	Demonstrate rapid knowledge discovery and structured argumentation in crisis management.
Sep 00	Demonstrate AIM automated collection strategy development and multi-asset planning at JEFX '00.
Sep 00	Demonstrate augmented CORBASEC. Demonstrate composable trust systems.
Sep 00	Demonstrate secure enclave-to-enclave collaboration. Demonstrate advanced intrusion detection and response capability integrated with dynamic system monitoring, control, and restoration.

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Sep 00	Demonstrate semi-automated templates handling incomplete data amidst 100 execution changes in a military exercise.
Sep 00	Demonstrate Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) automated collection strategy development and multi-asset planning Joint Expeditionary Force Exercise (JEFX) '00.
Dec 00	Demonstrate tools for analysis of IW attack costs.
Dec 00	Demonstrate system recognition of malicious code.
Feb 01	Experimentally evaluate JFACC-developed theoretical control techniques and tools completed, incorporating them into the final enterprise model. Validate the reduction in both time and disruptive effects to the air operations enterprise. Identify most promising C2 architecutural concepts, control strategies, and components for further validation.
Mar 01	Initiate development of selected components from new JFACC C2 architectural concepts and control strategies.
Mar 01	Demonstrate dynamic policy adjustment.
Jun 01	Demonstrate agents that dynamically create software interfaces; define scalability limitations.
Jul 01	Demonstrate CINC to tactical level integrated combined arms execution command and control with small unit synchronizing toolkit.
Sep 01	Demonstrate prototype adaptive security system and prototype DII I&W system.
Sep 01	Conduct evaluation of AIM's automated collection strategy development and dynamic multi-asset synchronization tools at Special Project '01.
Sep 01	Demonstrate that users can tailor their own templates, update information, add dependencies, and attach problem-solvers. Show that active template technology is scalable in that 50 templates have been built. Show that planning speed doubles and plan quality improves.
Jun 02	Demonstrate agent-based software technology for creating "super-applications" at run time.
Dec 02	Operationally evaluate integrated AIM capabilities for dynamic and proactive optimized collection strategy development, multi-asset synchronization for execution of the selected collection strategy, and continuous collaboration between operations and ISR.
Jan 02	Experimentally validate DC2 architectures and component design concepts.
Sep 02	Show six-fold increase in execution replanning using Active Templates attached to live data feeds from battlefield sensors.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Integration Systems CCC-02	89.071	85.343	49.654	38.131	32.246	34.512	35.837	Continuing	Continuing

(U) Mission Description:

(U) The goals of the Information Integration Systems project are to take diverse inputs, including those planned as outputs, from the PE0603762E Sensors and Exploitation Systems project (SGT-04), and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base, and through the use of wideband dissemination and integrated sensor management allow multi-site, real-time, collaborative situation assessment and course-of-action evaluations. These goals are being addressed by the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, and the Command Post of the Future (CPOF) program.

(U) The overarching goal of the Dynamic Database (DDB) program is to continuously produce significant battlespace information from immense quantities of multi-sensor data in a manner responsive to a diverse user community. More specifically, the DDB program will design, build, and demonstrate a system that (1) provides ready access to all battlespace sensor observations collected over time, (2) uses the resulting sensor history to identify and focus users' attention on tactically significant battlespace events, and (3) shares and synchronizes local situation changes across the distributed battlespace. Dynamic Database contents will be maintained and shared through a Sensor History Database (SHDB) that integrates geo-registered sensor history data with terrain, and potentially environmental, and force information to yield a logically consistent, multi-level view of the battlespace. Single and multi-sensor data fusion approaches will be developed that efficiently update the SHDB by filtering tactically significant changes from the Dynamic Database sensor history. This objective includes the development of theory and techniques for incorporating mission and situation context into low-level processing algorithms, and advanced phenomenology models for translating expected conditions and behaviors into multi-sensor observables. Significant situation changes will be shared throughout the battlespace within a scaleable Dynamic Database (DDB) enterprise of distributed Sensor History Database (SHDB) nodes, computing applications, processors, and information repositories. DDB enterprise technologies will be developed to monitor database conditions for change, trigger external processes when conditions meet posted criteria, propagate changes across DDB nodes, and support queries and searches of distributed databases.

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(U) The objective of the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD) is to integrate and demonstrate information management and battlefield awareness technologies that allow operational users to easily access and exploit an expanded, massive information flow, and for commanders to manage it. This operational prototype service will allow commanders to design/ tailor their own information environment, and provides access to key transmission mechanisms and worldwide data repositories. BADD will supply the warfighter with a description of the battlespace tailored to their mission needs by intelligent selection of information to be broadcast/delivered (e.g. Global Broadcast Service (GBS), broadband DISN and selected tactical networks), as well as intelligent processing of user requests (pull) and filtering at the warfighter workstation so that relevant/needed information is available. Selected applications and dissemination services will be transitioned to the Defense Information Systems Agency (DISA) for incorporation into the Defense Information Infrastructure Common Operating Environment (DII/COE). The Phase III (Technology Improvement) phase of BADD, renamed the Agile Information Control Environment (AICE), is developing and demonstrating breakthrough information management technologies that provide 10 times improvement in the efficient and timely delivery of information; that extend current information management services to support time critical and real-time information flows (e.g., sensor to shooter); and that optimize information flows based upon maximizing the value of information delivered vs. today's practice of maximizing the volume of data delivered.

(U) The Airborne Communications Node (ACN) program is developing a multifunction payload deployable on an airborne platform that can interconnect, much beyond current radio range (beyond line of sight and horizon), more than 70 different channels and 17 waveforms. This capability will provide tactical units with direct access to over-the-horizon communications capability and continuous broad area communications coverage over the battlefield, with cross-system connectivity amongst on-the-move warfighters – to include Joint and Coalition forces - significantly improving rapid force projection, synchronization and synergy. To connect isolated and rapidly maneuvering forces via high data rate communications, provide reach-back connectivity to CONUS from forward elements, allow gateway connectivity among dissimilar radios and support secure channel-based dynamic configuration control requires the development of a system capable of providing reliable service in a severe electromagnetic interference (EMI) and jamming environment. This is achieved through the development of a highly flexible, software reprogrammable radio communication system that incorporates a complex cosite mitigation approach. The system is designed to be flexible and scalable to any airborne platform, including tactical UAVs and manned platforms, for rapid deployment, thus enhancing the existing legacy communications capability, providing new commercially-derived services (i.e., cellular) and enabling support for the small unit operations and mobile command centers of the future.

(U) The objective of the Command Post of the Future (CPOF) program is to improve the speed and quality of command decisions, more effectively disseminate command decisions, and reduce the number of staff members required to process and manage the information systems

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required to do so. Three important command functions will be addressed in order to achieve this objective: 1) improved speed and quality of situation awareness; 2) improved speed of course of action (COA) development and selection; and 3) improved clarity of COA communication between commander and subordinates. For each of these command functions, CPOF is developing technologies that leverage the expertise of the commander by exploiting and augmenting natural cognitive abilities. The approach is to provide a very intuitive, well integrated, decision-centered, information environment in which the commander and a few staff members can quickly understand the changing battlefield situation, select the best course of action (COA), communicate that COA to the implementing units, and monitor the execution. The key technologies to be developed are: (1) an integrated visualization environment where the commander and his staff can view immediately understandable presentations of the changing battlefield situation, presentations which are tailored to the situation and the command decisions of interest; (2) a powerful and comprehensive human-computer interaction capability (through speech and gesture understanding, language understanding, dialog management, and visual collaboration) so that the commander and his staff can successfully understand and explore the information environment, without requiring dozens of staff members to operate and integrate multiple information systems; (3) a command post dialog manager which would automatically track current activities and tasks in the command post to tailor the information presentations to topics of interest; (4) an integrated suite of knowledge bases, intelligent agents, plan sentinels, information processing assistants which would automate many of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of hardware and software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of command.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Dynamic Database (DDB). ($ 23.598 Million)
  - Completed the initial DDB architecture design. Developed and conducted experiments of single-sensor entity phenomenology models.
  - Developed prototype multi-sensor target phenomenology models. Incorporated situation context into single and multi-sensor anomaly detection algorithms.
  - Demonstrated a prototype update service for the entity layer of the Dynamic Database.

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- Integrated technology products in the Dynamic Database (DDB) System Integration Laboratory (SIL) and demonstrated an initial DDB system capability that ingests raw multi-sensor data, aligns, and mosaics the data within a common 2-D spatio-temporal reference frame and provides the user ready access to sensor history data.
- Conducted a multi-sensor data collection at the National Training Center in conjunction with the XVIII Airborne Corps 525th Military Intelligence (MI) Brigade. Sensor types included Synthetic Radar (SAR), Electro-optic (EO), Infrared (IR), Ground Moving Target Indicator (GMTI) Radar, and Signals Intelligence (SIGINT) from a mix of currently fielded and advanced technology sensors platforms. Data from this collection was used to develop fusion algorithms and assess robustness of DDB technology.

- BADD ACTD. ($ 11.457 Million)
  - Deployed Battlefield Awareness and Data Dissemination (BADD) software to PACOM and began the operational utility assessment.
  - Integrated the BADD software with the DISA Information Dissemination Manager (IDM) COTS/GOTS products in preparation for fielding to selected CINCS in 3d Qtr FY 00.
  - Initiated formal segmentation of the BADD/DISA products for integration into the Defense Information Infrastructure (DII) Common Operating Environment (COE) and the Global Command and Control System (GCCS).
  - Delivered the battlefield Awareness video archiving tools to the Joint Staff Service Center (JSSC) for installation and CINC utilization.
  - Conducted four collaborative assessments with operational users at multiple agencies/distributed service sites (Army, Navy, Air Force, Special Operations Force (SOF) and Joint).
  - Began the two-year ACTD sustainment phase.
  - Conducted pilot services at SPAWAR San Diego, Hurlburt AFB, FT Gordon, ACOM, Joint C4SIR Battle Center (JBC) and CECOM.

- AICE. ($ 19.460 Million)
  - Theoretical Framework and Metrics: Developed comprehensive AICE Functional Architecture baseline. Coordinated, standardized and documented all major interfaces in AICE. Developed performance assessment methodologies and metrics to permit controlled scientific evaluation of AICE technologies.
  - AICE Technology Development: Developed AICE technology components which span the AICE Functional Architecture. Began developing prototype MetaNet consisting of tactical networks (MSE, CEC, and LINK16), DISN networks, and commercial networks. Developed information channel building and instantiation of information channels on commercial ATM and military EHF SATCOM

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networks with mission-driven quality of service. Began development of information flow optimization technologies for global, content-based information utility maximization. Developed formalism for hierarchical resource allocation policy expression and resolution against mission objectives. Developed a generalized specification of the metadata attribute space over which policies are applied. Developed the multi-dimensional vectorspace-based algebra required to achieve other AICE technical goals.

- Performance Assessment and Integration: Developed Performance Assessment Environment and defined experiments to evaluate and spur improvement of AICE technology components. Developments supported AICE component Build 1.

- Airborne Communications Node (ACN). ($ 21.933 Million)
  - Initiated the design, development, and integration the proof-of-concept payloads (three system design teams).
  - Continued ACN technology integration and experimentation, and conducted lab demonstrations to verify mitigation approaches/designs for high-risk areas such as electromagnetic interference (EMI)/cosite and antenna coupling/range.

- Command Post of the Future (CPOF). ($ 12.623 Million)
  - Began development of CPOF technologies, an integration environment, and designed a series of decision experiments to test the effectiveness of the CPOF system to improve command decisions. Technology development in automated visualization, multi-modal interfaces, automated context tracking, and dialog management was begun. Detailed studies of mental models of command decision making were begun and first cut encoding of these models into a functional abstraction hierarchy (FAH) was started. A detailed system integration plan was developed. Detailed experiment planning was begun with extensive interaction between the principal investigators (PIs), representatives from the battle labs (principally, the Marine Corps Warfighting Lab and the Army's Battle Command Battle Lab), and the CPOF senior advisory group made up of retired senior military commanders from all services. Development of the first version of the CPOF integration environment was begun.

(U) FY 2000 Plans:

- BADD ACTD. ($ 7.418 Million)
  - Complete the integration effort with DISA's products. Field BADD/DISA products to selected CINC's six months prior to the end of the ACTD. Continue upgrading capability (based on warfighter input/feedback) to provide a more enhanced version to the CINC's in the latter part of the FY. Provide interfaces that will allow other ACTDs and programs to take advantage of the BADD capabilities. Upgrade the software to be compliant with the DISA next iteration of the DII COE. Transition capability to DISA.

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- AICE. ($ 3.210 Million)
  - Complete closeout of AICE in concert with BADD ACTD transition.

- Dynamic Database (DDB). ($ 25.445 Million)
  - Complete a refined DDB architecture design that prototypes a single node DDB System Integration Laboratory (SIL). Expand the Sensor History Database (SHDB) object schema to include pedigrees that automatically map entity-level situation assessments to multi-sensor source data using data-driven fusion methodologies.
  - Extract and fuse enhanced multisensor data features over time. Include visible Electro-optic (EO) into the stored data-types. Develop and validate multiple-sensor terrain and entity phenomenology models. Validate prototype multi-sensor target phenomenology models.
  - Incorporate situation context into single and multi-sensor anomaly detection algorithms.
  - Demonstrate an interactive prototype update service for the entity layer of the Dynamic Database.
  - Explore alternative concepts for detecting/recognizing significant change and activity from multi-source data.
  - Upgrade technology products in the DDB SIL. Demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the SHDB, and provides the user ready access to Synthetic Aperture Radar (SAR), Electro-Optic (EO), Infrared (IR), Ground Moving Target Indicator (GMTI) Radar, and Signals Intelligence (SIGINT) sensor history data registered to a common fiducial and entity-level situation hypotheses.

- Command Post of the Future (CPOF). ($ 16.662 Million)
  - Produce technology in the areas of automated visualization, multi-modal interaction (speech and gesture recognition) automated context tracking, dialog management, and cognitive modeling.
  - Cognitive visualization principles will be encoded in a knowledge base and the tools for extracting and using these principles will be developed.
  - Tools for recognizing speech and 2D gesture interactions will be developed as well as higher order sketch understanding.
  - Automated context tracking will encode the mental models captured in the functional abstraction hierarchy (FAH) and develop technologies for isolating and tracking cues for indexing the FAH.
  - Continue development and refinement of the command decision making mental models and encode them in the FAH.

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- Complete the first series of limited objective experiments (LOEs) and conduct a comprehensive experiment in conjunction with a major warfighting experiment.
- Phase II experiments will be designed and a number of the phase 2 LOEs will be run.
- The integration environment will be complete and individual technology components will be added.

- Airborne Communications Node (ACN). ($ 32.608 Million)
  - Down select up to two teams for technology enabling payload architecture and development. This architecture will be targeted to operate within the stringent environment of the Global Hawk high altitude endurance unmanned aerial vehicle, thereby stressing the packaging technology required to meet the form, fit and function. The payload architecture will be modular and scalable, which will enable subsets of the full functionality to be transferred to other SWAP-limited platforms like tactical UAVs.
  - Conduct laboratory demonstrations of critical subsystems (e.g., interference mitigation subsystem).

(U) FY 2001 Plans:

- Dynamic Database (DDB). ($ 12.240 Million)
  - Extend database query services to include rapid access to all levels of situation information in response to pre-defined user profile requested content-based index and query capabilities.
  - Continue to upgrade technology products in Dynamic Database (DDB) System Integration Laboratory (SIL). Demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Sensor History Database, and provides the user ready access to Synthetic Aperture Radar (SAR), Electro-optic (EO), Infrared (IR), Ground Moving Target Indicator (GMTI) Radar, and Signals Intelligence (SIGINT) sensor history data registered to a common fiducial and both entity and force level situation hypotheses.
  - Incorporate Dynamic Database (DDB) technology into the XVIII Airborne Corps, 525th Military Intelligence Brigade, and Forward Sensor Enclave testbed.
  - Develop algorithms for multi-modal data fusion from visual systems and related feature recognition in a specific task domain with real-time requirements.
  - Nonlinear techniques for automatic audio recognition and feature extraction in noisy, multi-speaker environments.

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- Build an open plug-and-play architecture where modalities are mixed and matched to best support the target environment.

- Command Post of the Future (CPOF). ($ 24.861 Million)
  - Continue to develop and integrate new CPOF technology into a complete CPOF system to enable commanders to improve the speed and quality of command decisions to stay ahead of the adversary's ability to react.
  - Integrate and test new versions of the technology components in a series of simulation-based decision experiments.
  - Integrate the most effective technology into a complete CPOF system for an end-to-end demonstration of in a simulated joint exercise.
  - Begin preparations for an operational demonstration of the CPOF system in a joint field exercise in FY 2002.

- Airborne Communications Node (ACN). ($ 12.553 Million)
  - Complete development of critical technologies.
  - Verify the critical technologies at the component level.
  - Mature the ACN architecture to a preliminary design.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Dynamic Database:	
Oct 00	Incorporate Dynamic Database DDB technology into XVIII Airborne Corps 525th MI Brigade Forward Sensor Enclace (FSE) Testbed.
Jun 01	Demonstrate an interactive DDB system that ingests raw multi-sensor data, aligns, mosaics and displays the data within a 3-D Spatio-temporal reference frame in the System Integration Laboratory (SIL).
Aug 01	Preliminary architecture for sensor-to-sensor cascaded exploitation and tasking.

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Battlefield Awareness And Data Dissemination:

Apr 00	Field BADD products to selected CINCs.
Sep 00	Complete BADD ACTD transition to DISA and the Services.

Agile Information Control Environment:

Apr 00	Complete AICE theoretical framework.
Sep 00	Demonstrate AICE prototype MetaNet.

Airborne Communications Node:

May 00	Down select to two ACN teams.
Jan 01	Interim review and initial laboratory test data.
Sep 01	System performance review and simulation test results.

Command Post Of The Future:

Aug 00	CPOF Comprehensive Experiment One run in conjunction with Advanced Warfighting Experiment (AWE).
Jul 01	CPOF Comprehensive Experiment Two to run at Fort Hood in warfighting experiment.
Dec 01	Demonstrate Course of Action (COA) level analysis within major Army exercises (e.g., Advanced Warfighter Experiment - AWE).

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, R-1 #46

COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	199.445	177.598	182.225	203.424	229.482	254.396	276.896	Continuing	Continuing
Guidance Technology SGT-01	32.868	19.866	22.173	22.199	32.964	33.514	36.564	Continuing	Continuing
Aerospace Surveillance Technology SGT-02	60.204	40.722	61.545	78.838	88.232	90.550	109.300	Continuing	Continuing
Air Defense Initiative SGT-03	24.430	38.141	24.301	19.667	30.000	37.750	38.200	Continuing	Continuing
Sensors and Exploitation Systems SGT-04	81.943	78.869	74.206	82.720	78.286	92.582	92.832	Continuing	Continuing

(U) Mission Description:

(U) The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project is leveraging geolocation technologies to enhance the navigation and/or guidance packages of airborne platforms, ground vehicles and weapons. These improved systems will improve the accuracy and effectiveness of stand-off weapons, minimizing collateral damage while reducing the cost-per-kill.

(U) Aerospace Surveillance Technology programs are developing technologies to improve the accuracy and timeliness of surveillance systems in all weather, in hostile reception environments, and when necessary, in a covert manner. The programs funded by this project exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, high performance computing and low cost micro-electronics technologies.

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(U) The Air Defense Initiative is an on-going project whose overall goal is to reduce the proliferating cruise missile threat and enhance the survivability of US assets in the face of enemy electronic countermeasures.

(U) The objective of the Sensors and Exploitation Systems project is to provide the warrior with situational awareness and battlefield dominance by developing key sensor technologies; provide near-real-time semi-automatic exploitation of wide-area moderate resolution imagery data; provide real-time and accurate battlefield assessment and semi-automated precise and reliable target recognition and targeting of critical moving targets.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	209.971	232.319	211.893
Current Budget	199.445	177.598	182.225

(U) Change Summary Explanation:

FY 1999 Decrease due to SBIR and Omnibus reprogrammings, rescission (Section 8058), and minor repricing.
FY 2000 Decrease reflects Congressional adjustments, government-wide rescission and inflation reductions.
FY 2001 Decrease reflects reduction in scope of the Organic Ground Moving Target Indication program and rephasing of the Low Cost Cruise Missile Defense and Discoverer II efforts. The SAR ECCM program completion was accelerated to FY 2000 vice FY 2001 as previously planned. Other reductions are due to inflation adjustments and the minor repricing of ongoing programs.

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Guidance Technology SGT-01	32.868	19.866	22.173	22.199	32.964	33.514	36.564	Continuing	Continuing

(U) Mission Description:

(U) Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program. The Global Positioning System (GPS) Guidance Package (GGP) technologies funded in this project are applicable for both new or retrofit guidance/navigation packages for a variety of airborne platforms, ground vehicles, surface-to-surface standoff weapons and air-to-surface weapons. Additional thrusts are also included in this project to increase the ability of GPS users to operate effectively in presence of enemy jamming; to increase the versatility of navigation systems applications by developing micro-electromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation (Advanced Tactical Targeting Technology Program).

(U) GGP tightly integrates a miniature GPS receiver and an all solid state, low cost, navigation-grade, interferometric fiber optic gyroscope (IFOG) based miniature inertial measurement unit (MIMU) with an advanced navigation computer into a low cost ($15,000), precision navigation system. GGP Phase I addressed the technology issues involved in: (1) miniaturizing navigation grade inertial measurement units (IMUs) into a compact, manufacturable configuration; and (2) developing a multi-channel-on-chip, high dynamics GPS receiver. A Memorandum of Agreement (MOA) has been signed and implemented to demonstrate a Phase 1 unit on an Army Fire Support Team Vehicle (FIST-V). Successful demonstrations were conducted at Redstone Arsenal in June 1995 using a M981 FIST-V. Successful demonstrations also were conducted on an F/A-18. These tests assessed the performance of tightly coupled systems in high dynamics and validated Phase 1 design scenarios. GGP Phase 2 requirements place more stressing demands on performance of MIMU components and call for further reductions in size, power and weight. The Phase 2 was structured and continues as a competitive program with two prime contractors.

(U) The GGP program also will increase the ability of GPS users to operate effectively in the presence of enemy jamming or countermeasures (Global Positioning Experiments – GPX). It will demonstrate feasibility of airborne pseudolite (APL) concepts, which would sustain the availability

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of GPS signals to users in the presence of enemy jamming. The considerably increased transmit power of the APL fights off the effects of jamming on DoD receivers. APLs can be rapidly deployed on unmanned aerial vehicles (or other airborne platforms) and provide theater-wide coverage for individual soldiers, combat platforms and precision GPS-guided shoot-to-coordinate weapons. The project assesses three key challenges. First, it will demonstrate non-Keplerian orbit predictions of the APL and show that only software modifications are needed for GPS user receivers. Second, the APL must also accurately navigate using GPS satellites in the presence of jamming. Accordingly, this project provides for the design, development and demonstration of a low cost, space-time adaptive beamforming anti-jam receive antenna and a digital adaptive beamformer. With advanced algorithms, this will support greater than 45 dB nulls against up to six different jammers. Third, it is necessary to control the desired area coverage of APL transmissions. This will require demonstration of an advanced beam shaping transmitter antenna, precise management of the radiated power and the associated command and control structure.

(U) The Microelectromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, light weight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 will perform the following: (1) design and develop higher performance MEMS inertial gyroscope and accelerometer sensors, (2) select and refine foundries/foundry processes, (3) design the mechanical subsystem, and (4) select/refine the navigation software and perform INS simulations of the modeled sensors. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field. Three prime contractors are proceeding in Phase 2.

(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD). Today's threat radar targeting systems employed for SEAD fail to provide the rapid and accurate emitter geolocation needed to replace dedicated anti-radiation missiles (ARM) with generic, shoot-to-coordinate, smart weapons (e.g., JDAM or JSOW). The targeting system must negate emitter shutdown tactics now employed to defeat ARM guidance and enable simplified ordnance inventories. Generation and distribution of near real-time (e.g., seconds) comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any extra, SEAD dedicated, emitter collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combatant aircraft. AT3 will integrate in real-time the distributed multi-platform emitter collections using existing or planned tactical radios with advanced network management and signal processing. Additionally, to achieve the necessary wide deployment, AT3 self-contained collection packages must impose negligible burden on their airborne hosts and be available at affordable prices. Enabling technologies now in development at DARPA will be used, including highly agile digital

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receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS packages and advanced highly dynamic data fusion network management capabilities. Critical system advancements are (1) generating the commonly registered, theater-wide absolute doppler corrections to collected data and (2) managing the extraordinarily dynamic real-time data network including individual user kinematics and a changing aggregate participating user population.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- GPS Guidance Package (GGP). ($ 12.905 Million)
  - Maintained a second source for the GGP, thereby continuing as a competitive program.
  - Performed final integration and testing of GGP units.
  - Proceeded with adaptive signal processing/beamformer to null jammers.
  - Evaluated ranging accuracy of airborne GPS pseudolites.

- Microelectromechanical Sensor Inertial Navigation System (MEMS INS). ($ 8.292 Million)
  - Iterated MEMS foundry inertial sensor fabrication and initiated preliminary sensor testing.

- Advanced Tactical Targeting Technology. ($ 11.671 Million)
  - Completed AT3 preliminary design and system simulation.

(U) FY 2000 Plans:

- GPS Guidance Package (GGP). ($ 3.978 Million)
  - Complete evaluation of the feasibility of pseudolites; continue and complete adaptive signal processing and digital beamformer.

- Microelectromechanical Sensor Inertial Navigation System (MEMS INS). ($ 7.745 Million)
  - Begin MEMS INS integration with navigation software to demonstrate INS operation.

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- Advanced Tactical Targeting Technology. ($ 8.143 Million)
  - Complete Advanced Tactical Targeting critical design and begin fabrication.

(U) FY 2001 Plans:

- GPX. ($ 3.970 Million)
  - Complete development and evaluation of elements of the pseudolite network.
  - Initiate integrated demonstration.
- MEMS INS. ($ 5.955 Million)
  - Complete demonstration of MEMS INS operation.
- Advanced Tactical Targeting Technology. ($ 12.248 Million)
  - Complete fabrication and ground tests.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Apr 00	Complete AT3 critical component demonstrations and begin brassboard fabrication.
Aug 00	Deliver GPS Guidance Package (GGP) units to the Government.
Oct 00	Deliver GGP units to the Government (second source).
Oct 00	Complete laboratory test of digital adaptive beamformer.
Jun 01	Complete evaluation of pseudolite elements.

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Sep 01	Complete AT3 ground tests.
Feb 02	Complete demonstration of MEMS INS operations.

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aerospace Surveillance Technology SGT-02	60.204	40.722	61.545	78.838	88.232	90.550	109.300	Continuing	Continuing

(U) Mission Description:

(U) This project funds space and airborne sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, low-power high-performance computing, and low-cost micro-electronics to develop advanced surveillance and targeting systems. Surveillance is not an end to itself but rather an enabler for force protection and precision strike. Therefore a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The Millimeter Wave Targeting & Imaging System (MMWTIS) program will develop and demonstrate the targeting and imaging technologies to enable a low-cost, all weather, day/night precision targeting approach against moving or stationary targets at millimeter wave (W band) frequencies. The technologies investigated will include active and passive techniques to achieve high resolution targeting (low circular error probability (CEP)) and imaging (1-3 m). An objective system could be used for weapons targeting, high-resolution imagery, and battle damage assessment. This program will pursue advanced radar algorithms and sparse aperture concepts, and intelligent incorporation of miniaturized monolithic integrated circuit (MMIC), advanced W band power amplifier technology, radio frequency photonics technology and low power high performance computing.

(U) The DARPA Digital Radio Frequency Tags program will develop a flexible, potentially low cost technology to allow radars (Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR)) to receive data from ground devices. This program will develop a small, lightweight and affordable RF tag for data exfiltration from unattended ground sensors and communication with vehicles and personnel throughout the battlespace. This is particularly useful for the identification and location of coalition units. Additionally, the Digital RF Tag architecture can be exploited for other missions, with the net effect of substantially enhancing US situational awareness advantages.

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(U) The goal of the Adaptive Spectral Reconnaissance Program (ASRP) is to build the technical underpinnings for future multispectral and hyperspectral systems to counter camouflaged and concealed surface targets. The program is a jointly funded DARPA/Army (CECOM) effort. ASRP will develop the technologies for real-time detection of tactical targets employing concealment, camouflage, and deception (CC&D) using hyperspectral sensor data to cue high resolution, geo-located, target imagery. DARPA will develop algorithms, models, and phenomenology databases for use primarily in the visible through near infrared (VNIR) and short wave infrared (SWIR) bands to provide daytime capability, while the Army will focus on development of advanced long wave infrared (LWIR) sensor technology that will eventually enable nighttime capability. ASRP will employ an airborne testbed to validate the technology elements being developed and the overall technical concept of a real-time hyperspectral technology-based tactical directed area search capability. ASRP will leave behind validated performance prediction tools, specifications for validated robust low false alarm rate target detection algorithms, a real-time processor system, validated target detection in the VNIR/SWIR, and a database of targets and backgrounds.

(U) The Discoverer II program is a DARPA, Air Force and National Reconnaissance Office (NRO) joint initiative to develop and demonstrate an affordable space-based radar (SBR) with Ground Moving Target Indication (GMTI) and Synthetic Aperture Radar (SAR) imaging capabilities that will revolutionize reconnaissance, surveillance and precision geolocation support to the tactical warfighter. Discoverer II is the direct descendant of the DARPA STARLITE initiative. In January 1998, the Defense Science Board (DSB) Task Force on Satellite Reconnaissance issued its report. The Task Force recommended that a modified STARLITE program be initiated, as a "Military Space Radar Surveillance Program," in an effort to achieve broad-area, all-weather, near-continuous radar access that could be integrated with military operations. Two central findings of the Task Force were that an on-orbit demonstration would likely be needed; and that a technical risk reduction program should be undertaken in advance of the demonstration to bring leading edge, higher risk technologies to bear to both meet warfighter needs at lower cost, and to enhance system maturity thereby facilitating a more direct and rapid transition to a follow-on operational system.

(U) Discoverer II is a staged technology R&D demonstration program. In the first phase industry will conduct detailed trade studies necessary to define both an affordable objective space-based radar system for the 2010 timeframe and a demonstrator system for the 2005 timeframe that shows that it addresses the highest risk of the proposed objective capability. Concurrent with the performance of trade studies by Discoverer II system integration contractors, results of the risk reduction efforts will be exploited to ensure Discoverer II R&D demonstration can be pursued with acceptable risk. Specifically, the technologies to be pursued include: 1) developing a low-cost, multi-mode GMTI/SAR space-qualified electronically scanned antenna, 2) developing low power Microelectromechanical Systems (MEMS) for scanning radar modules (10x reduced power requirement), and 3) sparse band processing for data compression allowing on-ground processing with moderate rate communications links, and Automatic Target Recognition (ATR) quality range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar

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(IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and precision guided munitions (PGM) targeting (precision geolocation accuracy theater wide). If industry trade studies, informed by the results of the Discoverer II risk reduction initiatives, show an affordable objective system is achievable, Phase II will build and fly two GMTI/SAR technology demonstration satellites. The R&D demonstration will validate the technical feasibility of advanced C4ISR capability complementing/extending current Unmanned Air Vehicle (UAV)/Aircraft architectures. The demonstration will show how an objective system can provide deep-look access to denied area, and near continuous coverage from diverse look angles over the battlefield. Objectives for the demonstration include mobile target detection, tracking, and targeting; intelligence preparation of the battlefield; wide area search and precision engagement with direct downlink to the warfighter. The Discoverer II demonstration program will allow the joint community to make an informed decision on future operational Space Based Radar after the FY 2005 flight demonstration.

(U) The Novel Antennas Program is developing novel techniques to produce small, lightweight systems with low power requirements that are capable of locating specific emitters in a dense interference environment. The program will leverage major investments already made in photonics, antennas and space-time adaptive array processing with the latest advances in digital receivers, signal processors, and devices employing superconductivity. Both centralized and distributed sensor/array architectures are being explored. Prior to FY 1999 the program funding was distributed amongst the component technology development programs. During FY1999, the distributed architecture was refined to include spectrum supremacy, the ability to deliver novel radio frequency (RF) capabilities to organic ground combat vehicles (e.g. Abrams tanks, HMMWVs).

(U) Underground Facilities (UGFs) are being increasingly employed to hide a variety of strategic functions, including command and control and weapons of mass destruction associated activities. The Counter-Underground Facilities program (CUGF) will develop technologies to characterize UGFs: identification of facility function, UGF pace of activity, pre-attack status of the facility, trans-attack activities, and post-attack status. Techniques will be developed to determine locations of critical systems (power, water, airflow vents), orientation and depth of structure, and pre-strike and post-strike changes in the substructure resulting from attack. Additionally, techniques will be developed for effluent detection and monitoring. Candidate technologies include, but are not limited to, low frequency electromagnetics, multi/hyperspectral imaging, seismic imaging, and coherent passive seismic, acoustic and electromagnetic monitoring.

(U) Non-Linear Radar Communications Mapper (NLRCM): High valued camouflaged targets usually have radio transceivers for command and control purposes. To avoid detection, an attempt is frequently made to operate these radios primarily in the receive mode and to minimize radio transmission. Exploiting nonlinearities in the radio receiver, it may be possible to design a radar to detect and locate these radios while they are in the receive mode or possibly while they are in a standby mode. It has been postulated that if a radio receives a high powered tone, due to

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nonlinearities in the receiver, it will reradiate an intermod of the received frequency and the frequency to which it is tuned. Alternatively, if two tones are received, the radio will transmit an intermod of the two received frequencies. The radar systems concept is to develop either an airborne or satellite pulse Continuous Wave (CW) radar to detect, locate and map the locations of radio equipment based upon their nonlinear intermod behavior. This program will exploit legacy communications technology developed under the Novel Antennas program into various application domains.

(U) The Large Millimeter Wave Telescope (LMT) program will develop the largest (50 meter aperture) fully steerable millimeter wave radio telescope built to date. The design features a sophisticated laser metrology system to maintain precise alignment of the optics, and real time closed loop adaptive control actuator system to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) Program Accomplishments and Plans:

(U) FY1999 Accomplishments:

- Millimeter Wave Targeting & Imaging System (MMWTIS). ($ 1.790 Million)
  - Completed concept development studies.

- Radio Frequency (RF) Tags. ($ 7.539 Million)
  - Completed development and testing of ID-only RF Tags for use with Synthetic Aperture Radar (SAR) and Moving Target Indicator (MTI) airborne radar platforms.
  - Continued design of data encoding and extraction algorithms for tags. Conduct design trades for miniaturizing the tags.
  - Initiated digital tag development.

- Adaptive Spectral Reconnaissance. ($ 5.630 Million)
  - Initiated development of end-to-end spectral model to include real/synthetic imagery generation, atmospheric/path radiance components, and sensor models, platform dynamics and algorithm segments.
  - Conducted joint data collects in Southeastern US (Eglin AFB) and Southwestern US (National Training Center, Yuma Proving Grounds, and at Nellis AFB as part of JEFX 99 exercise).
  - Achieved airborne real-time cued target detection using VNIR/SWIR hyperspectral sensor.

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- Continued data analysis and creation of spectral target and background signature database.
- Continued algorithm development, including implementation of fusion methodologies to reduce false alarms.
- Awarded contract for development of compact high sensitivity long wave infrared (LWIR) hyperspectral sensor with high resolution imager.

- Discoverer II. ($ 31.476 Million)
  - Supported jointly funded effort to conduct design trades and analyses leading to the candidate objective system and demonstration system designs by awarding three system integration (SI) contracts in Feb 1999. Core activities focused on cost/performance trades and completion of an Integrated Master Plan/Schedule. The initial Interim Evaluation Review was conducted in 4th quarter FY 1999.
  - Supported jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing, and exploitation software. Completed Thinned Transmit/Receive (T/R) Module Electronically Scanned Array (ESA) design.
  - Conducted mission utility analyses and concept of operations studies.

- Novel Antennas. ($ 12.269 Million)
  - Pursued data collection, and demonstrated algorithm performance against emitters in a realistic interference environment (urban, desert and hilly deciduous forest). Urban and non-urban environments were explored. Distributed architectures were developed and assessed, supporting hardware developed and demonstrated, and algorithm performance was evaluated.
  - The integrated system design was developed.
  - Conducted an experiment to determine the utility/synergy of close access, distributed collection capability into a distributed architecture.
  - Employed networked sensors, which leverage software reprogrammable radio technology to assess the utility of distributed architectures.

- Large Millimeter Wave Telescope (LMT). ($ 1.500 Million)
  - Completed preliminary critical system design.
  - Completed site characteristic measurements through seismic and wind monitoring.

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(U) FY 2000 Plans:

- Radio Frequency (RF) Tags. ($ 6.349 Million)
  - Conduct a Preliminary Design Review (PDR) for a digital RF Tag, system level trade study, and technology insertion plan; continue development of data encoding and extraction algorithms.

- Adaptive Spectral Reconnaissance. ($ 3.978 Million)
  - Complete algorithm development, including implementation of new algorithms and hybrid fusion techniques.
  - Complete data collection, analysis and validation activities, including collects at Ft. A.P. Hill and Aberdeen Proving Grounds.
  - Complete validation of end-to-end visible through near infrared (VNIR)/short wave infrared (SWIR) spectral model including real/synthetic imagery generation, atmospheric/path radiance components, sensor models, platform dynamics, and algorithm segments.
  - Complete spectral target and background signature database and release for distribution.

- Discoverer II. ($ 13.288 Million)
  - Complete Phase I satellite design efforts with two system integration (SI) contractor teams. Conduct second and third Interim Evaluation Reviews culminating in preliminary designs for demonstration satellites.
  - Conduct mission utility analyses and concept of operations studies.
  - Built and tested sub-scale radar antenna designs, advanced signal processors, and exploitation software.
  - Fly radar payload simulator on airborne asset.
  - Plan for Phase II Request for Proposals (Source Selection in early FY01).

- Novel Antennas. ($ 2.167 Million)
  - Initiate analysis of next generation geolocation techniques technology for ground based communications exploitation.

- Counter-Underground Facilities. ($ 11.440 Million)
  - Initiate robust modeling of seismic-acoustic-electromagnetic and effluent signatures and backgrounds.
  - Initiate field measurements to verify phenomenology, validate models and explore sensor deployment concepts.
  - Initiate robust modeling of coherent passive seismic-acoustic-electromagnetic monitoring of UGFs.

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- Initiate system concept development and modeling for UGF monitoring via effluents.
- Initiate robust modeling of active electromagnetic techniques for UGF characterization.
- Evaluate concepts for active seismic UGF characterization and BDA with models and field experiments.
- Initiate field measurements to verify coherent seismic-acoustic-electromagnetic phenomenology and validate models.
- Begin comprehensive evaluation of sensor deployment concepts to enable characterization to support UGF functional defeat.

- Underground Facilities Detection. ($ 1.500 Million)
  - Pursue advanced concepts and technologies to improve underground facilities detection and characterization capabilities.

- Large Millimeter Telescope. ($ 2.000 Million)
  - Initiate pointing system control design.
  - Initiate full-system pointing error budget.

(U) **FY 2001 Plans:**

- Radio Frequency (RF) Tags. ($ 7.211 Million)
  - Complete Critical Design Review (CDR) for digital RF tag.
  - Conduct risk reduction tests.

- Discoverer II. ($ 40.107 Million)
  - Conduct Phase II source selection.
  - Begin performance of Phase II: System integration (SI) contractor complete detailed design of ground moving target indicator (GMTI) radar demonstrator system.
  - Initiate procurement of long-lead items for two GMTI/ synthetic aperture radar (SAR) demonstration satellites.
  - Continue on-going signal processing and target tracking algorithm development.
  - Continue software demonstrations.

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- Counter-Underground Facilities. ($ 6.948 Million)
  - Continue modeling of signatures and backgrounds.
  - Continue field measurements to verify model performance including seismic, acoustic, electromagnetic and effluent signatures and backgrounds, and evaluate underground facilities (UGF) characterization effectiveness.
  - Initiate prototype development activities for selected technologies.
  - Initiate on-site demonstration planning.

- Non-Linear Radar Communications Mapper. ($ 7.279 Million)
  - Perform assessments of nonlinear radar phenomenon to detect critical mobile targets under camouflage and underground facilities via non-linear scattering from their communications equipment and initiate system concept development.

(U) **Other Program Funding Summary Cost:** *(In Millions)*

Adaptive Spectral Reconnaissance:

Source	FY 1999	FY 2000	FY 2001
Army	3.200	4.000	1.900

Discoverer II:

Source	FY 1999	FY 2000	FY 2001
NRO	29.900	13.300	34.700
Air Force	15.500	13.300	54.600

(U) **Schedule Profile:**

Plan	Milestones
Radio Frequency (RF) Tags:	
Mar 00	Conduct Preliminary Design Review (PDR) for digital Radio Frequency (RF) Tag.
Sep 00	Conduct Critical Design Review (CDR) for digital RF Tag.

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Oct 01	Brassboard digital tag.
Dec 02	Prototype digital tag.

Adaptive Spectral Reconnaissance:

Dec 00	Complete validated visible through near infrared (VNIR)/short wave infrared (SWIR) model and tools.
Dec 00	Deliver VNIR/SWIR algorithm specifications (including detection, fusion and recognition).
Dec 00	Complete VNIR/SWIR data analysis and deliver phenomenology databases.

Discoverer II:

Mar 00	Interim Evaluation Review (IER) #2.
Apr 00	Award Continuation Option to Selected System Integrator (SI) Contractor(s).
Aug 00	Interim Evaluation Review (IER) #3.
Oct 00	Phase II RFP release.
Apr 01	Award Phase II SI contract for detailed design of the demonstration system.
Jun 01	Delta-Preliminary Design Review with SI.
Jun 02	System Critical Design Review (CDR).

Novel Antennas:

Apr 00	Final data collection.
Jul 00	Wideband link demonstration.
Sep 00	Transition.

Counter-Underground Facilities:

Mar 00	Initiate model development for seismic, acoustic, and EM and effluents.
Jul 00	Initiate model validation experiments.
Dec 01	Complete Model Validation for Seismic, Acoustic, EM, and effluents.
Mar 02	Initiate prototype demonstrations.

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Non-Linear Radar Communications Mapper Program:
Aug 01 Complete initial assessment of non-linear scattering of communications equipment.

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Air Defense Initiative SGT-03	24.430	38.141	24.301	19.667	30.000	37.750	38.200	Continuing	Continuing

(U) Mission Description:

(U) This project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These programs include the Synthetic Aperture Radar Electronic Counter-Countermeasures (SAR ECCM) program, the Low-Cost Cruise Missile Defense (LCCMD) program, the Adjunct Airborne Early Warning (Global Eye) program, and the Microelectromechanical (MEM) antenna (MEM-tenna) program, and the Air Directed Surface-to-Air Missile (ADSAM) program.

(U) The SAR ECCM program will develop techniques to make U.S. Synthetic Aperture Radar (SAR) systems less vulnerable to intentional enemy jamming or deception. SAR systems have become one of the most widely used broad area surveillance systems. They are critically important to the development of battlespace awareness and their jamming and/or deception could seriously degrade U.S. warfighting capability. The SAR ECCM program will determine the military impact of various SAR jamming techniques and develop countermeasures against the highest priority threats.

(U) The LCCMD program will employ existing and emerging technologies to develop an affordable missile interceptor. This interceptor is directed at defeating a threat consisting of unsophisticated air vehicles including cruise missiles, unmanned aerial vehicles, helicopters, and low flying aircraft that are capable of delivering conventional, chemical, or biological weapons and conducting jamming or surveillance missions. The program is focused on the development of low cost seekers which account for approximately 70% of the missile system's cost and present the greatest technological challenges. The program is pursing both an RF seeker solution (noise radar and pulse doppler) and a LADAR seeker solution. The most promising seeker in terms of cost, performance, and robustness will be integrated with a Miniature Air Launched Decoy (MALD), modified to serve as an interceptor, for live fire testing and transition to the Military Services.

(U) The Adjunct Airborne Early Warning (Global Eye) program will demonstrate the feasibility of multi-aperture, multi-function radar technology in UAVs. A UAV outfitted with this technology could provide lower cost (factor of 20), continuous air and ground surveillance of low intensity areas such as no-fly zones and peacekeeping areas. Such capability could supplement traditional AWACS and E-2C, and reduce the requirement to forward base large numbers of manned aircraft for these purposes. This program will also support the demonstration of the ability to

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get an order of magnitude more ground coverage in a GMTI mode through very wide-band off-board communications and large numbers of phase centers. The key technologies to be used are: MEMs filters for simultaneous transmit and receive and polarization diversity, high efficiency solid state transmitters, composite lightweight integrated antennas, and advanced mode control/interleaving algorithms. Concepts will be explored which use common components to perform both the AEW mission (at the reduced ranges appropriate to this concept), and air-to-ground modes. The latter will support networking concepts, which reduce cost and enable precision moving surface target engagement.

(U) The MEM-tenna program will develop an ultra-low cost; lightweight phased array antenna based on MEMS phase shifters and Digital Mirror Device technologies. MEMS technology can produce phase shifters for phased array antennas that are a small fraction of the power consumption of conventional PIN-diode or GaAs field effect transistor (FET) phase shifters, while also having low insertion losses. Hard-wired beam steering control and RF manifolds are replaced by optical and RF space-fed configurations. Using these technologies, very large-scale electronically scanned arrays (ESAs) can be developed for airborne, ship and space-based applications. Phase shifter designs incorporating MEMS technology are being developed, and these will be incorporated into a prototype ESA having 10,000 antenna elements, operating at X-band.

(U) ADSAM: The purpose of the joint DARPA/AMCOM/USMC/AMRAAM program office project is to rapidly demonstrate enabling technologies and operational concepts to support the destruction of low flying, stressing targets, such as cruise missiles. This project demonstrates the critical technologies required to destroy such targets beyond the line-of-sight and at the full intercept range of surface-to-air missile systems using an elevated platform to provide target cueing and updates to Advanced Medium Range Air to Air Missiles (AMRAAM). These missiles are ground launched from modified High Mobility Multi-Purpose Wheeled Vehicles (HMMWV) developed by DARPA and AMCOM, known as the HUMRAAM.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- SAR ECCM. ($ 7.309 Million)
  - Selected ECCM techniques were implemented for mitigating low-level ECCM threats in the analog (front end) and image domain portions of the radar. Data was collected to validate the calculated impacts and support further technique development. A laboratory demonstration of the selected ECCM techniques supported several high-level experiments using test and operational platforms.

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- LCCMD. ($ 14.376 Million)
  - The Government downselected from six to three low cost seeker concepts based on the results of contractor analyses and laboratory testing. The selected seekers are the noise radar seeker, the Microelectromechanical Electronically Steered Array (MEMS ESA) seeker, and the laser seeker. The noise radar seeker team successfully completed a Critical Design Review and has begun fabrication and integration of seeker hardware to be used for captive flight-testing. The MEMS ESA seeker team fabricated and tested a MEMS phase shifter. The phase shifter, the key technology required to fabricate the MEMS seeker antenna, exceeded performance requirements. The laser seeker team fabricated and demonstrated a brassboard seeker. The seeker exceeded range accuracy requirements and came very close to meeting angle accuracy requirements.

- ADSAM. ($ 2.745 Million)
  - Modifications to the HUMRAAM developmental system were completed. Analysis of the flight test results, comparisons to predictions and model modifications were completed. Technical lessons learned, including software and hardware, was transferred to the air defense community for future ADSAM live fires with other missiles (Standard Missile, Patriot, etc).

(U) FY 2000 Plans:

- SAR ECCM. ($ 9.004 Million)
  - The design and implementation of the selected ECCM techniques will be completed and demonstrated in a series of off-line final technique demonstrations. These demonstrated techniques will begin transition into selected operational platforms to mitigate the rising proliferation of inexpensive modern threat systems. The SAR ECCM program will be integrated into the annual Expeditionary Force Exercise.

- LCCMD. ($ 16.899 Million).
  - The noise radar seeker team will complete seeker fabrication, complete seeker ground testing, and initiate non-real time captive flight testing using an A-3 aircraft and tactically representative airborne targets. The MEMS ESA seeker team will complete a Systems Requirements Review, complete a Preliminary Design Review, and fabricate and test a tactically form-factored transmit/receive antenna. The laser seeker team will complete a Systems Requirements Review, complete an Interim Design Review, and field test a

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ground based laser system against tactically representative airborne targets. The Government will select a single seeker and initiate the fabrication of a form-factored seeker for live fire testing based on the results of analyses and tests conducted to date.

- Adjunct AEW. ($ 3.485 Million)
  - Begin the development and fabrication of a subarray portion of a prototype composite, lightweight, integrated phased array antenna to demonstrate that the desired antenna concepts can be implemented while also achieving the design goals of low weight and cost. Mode control/interleaving algorithms will be developed. Also, the preliminary design for a means of carrying a complete radar system on a UAV, such as the Global Hawk, will commence.

- MEM-tenna. ($ 8.753 Million)
  - Modify existing designs of MEMS X-band phase shifters and initiate prototype manufacturing. The design of a prototype ESA that will incorporate the completed MEMS phase shifters will also begin.

(U) FY 2001 Plans:

- LCCMD. ($ 13.474 Million)
  - The noise radar seeker team will complete non-real time captive flight testing and flight test data analysis. The flight test data will subsequently be used to demonstrate in the laboratory real time processing using a noise seeker processor developed by the program. Form-factored seeker fabrication will be completed. Planning for subsequent captive carry and live fire testing will be completed.

- Adjunct AEW. ($ 3.474 Million)
  - The completed subarray will be laboratory tested.

- MEM-tenna. ($ 6.353 Million)
  - Manufacture of a full-scale antenna using MEMS phase shifters will begin. A transmitter and beam controlling processor will be integrated with the array. Calibration techniques with specific and general applicability will be developed. Planning for the final integration and test planning will start.

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- Advanced Sensing Alternatives ($ 1.000 Million)
  - Explore advanced sensing modalities to solve stressing combat ID and countermeasure challenges, including, but not limited to, IR polarization diversity and active EO/IR.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
LCCMD:	
May 00	Start Laser Seeker Ground Testing
Jun 00	Start Noise Seeker Ground Testing
Sep 00	Start Noise Seeker Flight Testing
Sep 00	MEMS ESA Antenna Testing
Sep 01	Start Selected Seeker Captive Flight Testing
Mar 02	Selected Seeker Integration with Modified MALD
Sep 02	Selected Seeker Live Fire Testing Start
SAR ECCM:	
Aug 00	Field ECCM Demonstration
Adjunct AEW:	
Mar 00	BAA Issued for MEM filter
Jul 01	Complete basic subarray fabrication and lab testing

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MEM-tenna:

Mar 00	Begin design of 10,000 element MEM-tenna demonstration system
Dec 01	Complete production of 11,000 MEMS phase shifters

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Sensors and Exploitation Systems SGT-04	81.943	78.869	74.206	82.720	78.286	92.582	92.832	Continuing	Continuing

(U) Mission Description:

(U) The Sensors and Exploitation Systems project funds key sensor demonstrations and the development of systems to further exploit sensor products. These efforts, in conjunction with those described in Projects SGT-01, SGT-02, and SGT-03, seek to develop the systems needed to provide the warrior with situational awareness and precision target identification and attack capability. The strategic goals of this project are to: develop key sensor technologies required to support battlefield dominance, including sensors which can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic exploitation of wide-area moderate (and high) resolution imagery; provide real-time, accurate Battle Damage Assessment (BDA); and provide semi-automated recognition, robust, precise and reliable identification, and precision fire control tracking of high value units and critical moving targets. These goals are being addressed by the Counter CC&D Program; the Semi-Automated Imagery Intelligence (IMINT) Processing (SAIP) Advanced Concept Technology Demonstration (ACTD); Moving and Stationary Target Acquisition and Recognition (MSTAR) program; Surface Target Identification for Engagement (STRIDE); Moving Target Exploitation (MTE) Automatic Target Recognition (ATR) applications programs; Eyeball, a multispectral electro-optical (EO)/infrared (IR)/radar identification concept; Airborne Video Surveillance (AVS) program; Affordable Moving Surface Target Engagement (AMSTE) program; Real-Time Battle Damage Assessment (SAR BDA) program, and the Organic Ground Moving Target Identification (GMTI) Radar (OGR) program.

(U) The goal of the Counter CC&D Program is to significantly enhance the military's capability to detect obscured targets hidden under foliage and camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (detect 80% of the targets with 0.1 FA/sq.km) using a FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR is being developed for demonstration on a manned platform (Army RC-12) providing inputs via narrowband tactical data links for ground image exploitation. A Ground Control and Display Subsystem is being developed to provide real-time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing, and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended via the Multisensor Exploitation Testbed for FOPEN as well as Multi/Hyper Spectral Image sensor input, geolocation and multi-sensor fusion processing of images, and detection of time critical targets. The program will ultimately combine FOPEN SAR on the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle with other airborne sensors (e.g., the Senior Year Electro-Optical Reconnaissance System on the U-2) and modes (GMTI/passive detection), and develop integrated exploitation technologies for insertion into the CIGSS. Analyses are also being conducted to evaluate the

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capability for FOPEN Ground Moving Target Identification (GMTI) and Electronic Support Measures to increase the effectiveness of future Counter CC&D systems.

(U) The Semi-Automated IMINT Processing (SAIP) ACTD has developed, tested and is transitioning to the operational user, automated algorithms and semi-automated tools that enhance the warfighter's capability to: process SAR, and later EO, imagery; conduct wide-area search for Ground Order of Battle and Missile Order of Battle targets; perform rapid site modeling and site monitoring; and produce target reports in near real-time (< five minutes). Goals for the baseline system were automatic target cueing and classification for a limited set of vehicles (10 targets); object level change detection; force recognition to the company level; and interactive target recognition and terrain delimitation. Goals for the enhanced system were increasing the automatic target cueing and classification to 20 targets; site modeling and monitoring with EO and SAR; and addition of SIGINT cueing. The residual-fielded system has further increased automatic target recognition to 30 targets.

(U) The goal of the Moving and Stationary Target Acquisition and Recognition (MSTAR) program is to achieve a major advance in Automatic Target Recognition (ATR) performance based on the use of SAR imagery. This is accomplished through fundamental and innovative technology and algorithmic developments, large-scale data collections, and detailed system evaluations. The approach to detecting stationary targets utilizes traditional ATR techniques to first determine suitable target candidates for those image regions of interest (ROIs) that have been selected based on their likelihood of target content. A model-driven subsystem then refines these target candidates by using a SAR signature prediction module to determine the true target ID of the target within the ROI. Other program goals include: significant advances in tools including ATR tools and capabilities to efficiently perform interactive image exploitation; development of rapid target model construction technologies; collection and dissemination of high-quality databases of SAR signatures, development of resource management systems for surveillance and exploitation; and development and demonstration of compression-based techniques to reduce communication bandwidths for SAR-based wide area search platforms to SATCOM-supportable bandwidths.

(U) The Moving Target Exploitation (MTE) program, which ended in FY 1999, provided significant improvements to the exploitation of ground Moving Target Indicator (MTI) radar data by providing previously unavailable capabilities to automatically detect, track, and classify high-value ground-moving targets and maneuvering formations using all-weather airborne surveillance radar data. Four techniques were investigated and evaluated: automatic tracking of ground moving vehicles; automatic analysis of moving vehicle motion patterns and behavior patterns to identify purposeful military movement; discrimination of desired targets from other moving vehicles using high range resolution (HRR) MTI range profiling and 1-D automatic target recognition; and imaging of specific moving targets via enhanced moving target imagery (MTIm) processing. Specific applications were targeted for MTI sensors on board the Joint Surveillance, Target, and Attack Radar System (Joint STARS), U-2, and Global Hawk

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platforms. In addition, system-level approaches for the application of complex-data techniques were investigated, developed and integrated, including scatterer-specific imaging (SSI) for enhanced ATR with reduced false-alarm rates and systematic applications of coherent change-detection (CoCD).

(U) The goal of the Airborne Video Surveillance (AVS) program is to build and evaluate Airborne Video Surveillance technology to increase the tactical usefulness of video (visible and infrared) data from manned reconnaissance aircraft and Unmanned Air Vehicles (UAVs). The following semiautomatic capabilities will be developed: Precision Video Registration (PVR): real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery from areas representing multiple terrain types (desert, mountain, littoral) using standard reference imagery products from the National Imagery and Mapping Agency; Activity Monitoring (AM): reliable detection of specific events (soldier incursion, removal of vehicles from cantonment areas, etc.) of points, operations areas and lines of communication (LOC); and Multiple Target Surveillance (MTS): simultaneous tracking of multiple ground vehicles in the sensor platform area of regard but outside a single sensor field of view.

(U) The goal of the Affordable Moving Surface Target Engagement (AMSTE) program is to develop and demonstrate the technologies required to perform affordable, all-weather, precision negation of moving surface targets (both land- and sea-based), using netted tactical and theater ground moving target indication (GMTI) sensors. Weapons system architectures will be developed and integrated to support a series of precision fire control bomb-drop field experiments and demonstrations. In-flight midcourse and terminal guidance to weapons will also be implemented to demonstrate weapon system CEPs an order of magnitude below current systems against moving targets. Experiment results will be used to extrapolate performance using multiple weapon systems, including fighter-based weapons, long-range precision weapons, and gun launched weapons. The precise cueing from the netted GMTI sensors will allow for lower-cost weapons by reducing the complexity of precision munitions. Additionally, collateral damage will be minimized by virtue of very precise targeting and midcourse/terminal phase flight updates. Robustness of the precision fire control technology will be ensured through very low-cost seekers or adaptive warheads that can compensate if fire control dropouts occur. A number of critical technologies must be developed including unaided precision gridlocking techniques, low-cost weapon data links, low-cost weapon seekers and advanced multi-platform tracking algorithms for both precision and long-duration, high-confidence track purity using phenomenological features. Additionally, battle management, command, control, and communications (BM/C3) experiments will be pursued jointly with Service partners to enable rapid inclusion of precision targeting of movers into future operational architectures.

(U) The Eyeball program, a multispectral EO/IR/Radar identification concept, is founded on the fact that prospective radar assets will be able to detect, locate and provide some forms of target classification. Because of radar and signature limitations, the identification provided may be insufficient for actual targeting and allocation of attack assets. The Eyeball program will investigate novel concepts for standoff identification of

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moving targets by electro-optical sensors working in conjunction with air- and space-born radar Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) sensors. Once identified, the targets can be tracked using the same radar-based assets. This program will test sensors combining various degrees of spatial resolution, possibly with polarimetric and spectral sensitivity, to identify targets at standoff ranges. The program will also develop concepts for providing this capability on fielded and fieldable platforms.

(U) The goal of the Real-Time Battle Damage Assessment (R/T BDA) program is to develop and evaluate technology to permit all-weather, in-theater assessment of the effects of precision weapons on mobile threat targets such as surface-to-air missile launchers, theater surface-to-surface missile launchers, and multiple rocket launchers. R/T BDA will exploit organic and theater synthetic aperture radar sensors to assess effectiveness of munitions delivery and provide feedback to attack systems in mission, with a goal of providing weapon effectiveness metric feedback to the operator within 10 minutes of engagement. R/T BDA will also develop and demonstrate very low-cost, "pop-off" sensors deployed from incoming weapons at pre-determined times before weapon impact. R/T BDA will focus on identifying and assessing weapons effects from precision guided munitions, submunitions, sensor-fuzed weapons, and weapons that typically provide less energetic effect on the target and are, therefore, more difficult to assess by traditional BDA techniques.

(U) The goal of the Organic GMTI Radar (OGR) program is to develop the technologies to enable a low-cost capability for the detection and tracking of moving vehicles and personnel through foliage, using "organic" transmit assets for Army or Marine units. The goal is to detect vehicles at ranges of 10–20 km and personnel at ranges of 3-5 km with low false alarm rates. The concept is based on the use of separate transmitters and receivers, each of which is designed for low cost and portability. False alarm reduction and target tracking will be achieved through the creation of multiple narrow azimuth receive beams using high-speed digital beam forming computers. To ensure adequate foliage penetration, the system will be designed to operate in the VHF-UHF frequency regime. The ultra-miniature receivers located at each receive antenna array will be connected to the central signal processor via fiber optic links for ease of setup and to provide for the reduced cost and weight of the overall system. The use of commercial HDTV broadcasts, as a source of illumination energy will also be included in this effort.

(U) The goal of Surface Target Identification for Engagement (STRIDE) program is to achieve confirmed identification of surface targets through a combination of rapid deployment of "eyes-on-target" and new RF phenomonologies and modeling technology. STRIDE will develop and demonstrate affordable, rapid means for delivering electro-optical systems to perform primary or secondary identification of surface targets. Delivery means may include gun launching or deploying from existing deployment mechanisms such as towed decoy tubes. These capabilities will be optimally combined with advanced RF techniques to provide reliable, affordable identification under virtually all rules of engagement. Specific

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advanced RF techniques to be investigated include the use of ultra-high bandwidth, ultra-high resolution, and multi-look with angle diversity sensing.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Counter CC&D. ($ 32.372 Million)
  - The Counter CC&D Program completed system design and neared completion of component hardware development of the FOPEN SAR Manned Airborne Demonstrator. A critical design review of the integrated Multisensor Exploitation Testbed (MSET) has been conducted in preparation for FY 2000 development tests of FOPEN and SYERS MSI exploitation and Counter CC&D Tests. Advanced FOPEN and MSI/HSI ATD/C algorithms have been extended to provide increased georegistration accuracy and potential for reduction of false alarm density through sensor fusion. Analysis of FOPEN GMTI/ESM system concepts combined with a single-aperture FOPEN GMTI/ESM data collection to verify concepts and verify attenuation models at shallow angles has been accomplished.

- SAIP ACTD. ($ 13.488 Million)
  - The Semi-Automated IMINT Processing (SAIP) operational assessment was completed and the final transition configuration of the system stood up. Demonstration of all software upgrades was conducted. Interim operational capabilities were transitioned for integration into the US Air Force Flight Test Facility and to the Army ETRAC system.

- MSTAR. ($ 20.083 Million)
  - Using data from multiple collections, including Global Hawk data acquired through the Sensor Emulation Platform (SEP) and other SAR imagery sources, the 30 target MSTAR system with extended operating conditions (EOCs) was evaluated, making use of supercomputer resources. The system performs very well against targets that articulate, against targets with variable backgrounds, configurations, and variants. The system continues to work well as the targets are placed in dirt revetments or rotate and tilt, but fails to recognize targets that are more than 10% obscured by concrete emplacements. Targets in close proximity to one another also defeat the recognition system. A laboratory for experimentation and integration of MSTAR technology into SAIP has been established in the DARPA Technology Integration Center. A pair of data collections using the ERIM DCS Ultraresolution SAR Sensor has provided a

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collection of two-inch resolution SAR images of target vehicles and military scenes. A series of MSTAR Enhancement Projects (MEP), designed to explore the use of higher resolution, the addition of new signature features, extraction of targets from raw radar returns, and increased computational parallelization were also initiated. The Rapid Target Model Insertion project, which supplies the CAD models used by the MSTAR Predictor, demonstrated two separate target model insertions with each end-to-end process occurring within a two-week time period, representing a five-fold improvement over 1997 baseline insertion rates.

- Moving Target Exploitation (MTE). ($ 16.000 Million)
  - The MTE Program demonstrated the effectiveness of MTE on-board the JSTARS T3 Testbed against a complex set of military vehicles during the Air Force Expeditionary Force Exercise. The first build of the MTE-CGS ground station was completed and demonstrated using synthetic sensor emulation platform (SEP) data. A proof-of-concept study was conducted to assess the technology to support affordable, precise, moving surface target engagement. Weapon system trade studies were conducted to investigate communication requirements, weapon system CEPs for a variety of weapon systems, weapon cost reduction, battle management requirements, and low-cost sensor-to-weapon link designs.

(U) **FY 2000 Plans:**

- SAIP ACTD. ($ 4.538 Million)
  - Operational support to the Army and Air Force SAIP residual operational capability will be provided through the second quarter of FY 2000.

- MSTAR. ($ 15.921 Million)
  - Using newly collected SAR data, the MSTAR Enhancements Program will demonstrate major improvements in ATR performance as a function of resolution. Recognition capabilities using RF returns without forming the imagery will also be investigated. An integration and transition capability will be established in the Real Time ATR Laboratory (R/T ATR Lab) for the purpose of developing MSTAR based "modules" that can be used to upgrade operational ATR systems such as SAIP. The ability to operate the MSTAR system in near real time will be demonstrated through the use of parallel super-computers in the R/T ATR Lab. Concurrently, a toolkit of interactive exploitation tools, integrated with commercial technology, will provide operationally useful ATR capabilities to image analysts. Finally, an initial exploration will be conducted of MSTAR model-based reasoning technology using SAR data in conjunction with 3-D LADAR data of ground targets.

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- AVS. ($ 11.195 Million)
  - The Airborne Video Surveillance (AVS) program will integrate, demonstrate and evaluate, extensively in laboratory systems and in some limited field experiments, airborne systems in simulated military missions with these technology goals: Activity Monitoring – upgrade to monitor activities (e.g., soldier incursion into security zones, tactical and strategic vehicle movement) in larger areas and along extended lines of communication; Moving Target Surveillance – demonstrate increased reliability of target tracking/reacquisition and develop technology for the geolocation of moving targets in multiple varieties of terrain types and imaging conditions. Precision Video Registration – demonstrate 2 meter absolute error geolocation accuracy of 80% of mission imagery (from multiple varieties of terrain types) and imaging conditions similar to reference imagery (Class 1: less than 40 degree line of sight variation, good contrast, small seasonal variations), demonstrate similar accuracy on 75% of imagery exceeding this envelope (Class 2). Activity Monitoring and Multiple Target Surveillance will perform focused experiments in support of Army, Air Force and Navy users to cause technology transition.

- Counter CC&D. ($ 27.410 Million)
  - The Counter CC&D Program will complete hardware development and system integration, and will conduct preliminary flight tests of FOPEN SAR Manned Airborne Demonstrator on an Army RC-12 aircraft. This demonstration will verify that the system meets image quality with real time tactical data link operational constraints. The Multi-Sensor Exploitation Testbed will focus on the development of SAR and spectral MSI image feature fusion techniques to demonstrate the achievable performance gain in overall detection and false alarm rate with multimode systems. These capabilities will be utilized with the ATD/C algorithms to demonstrate and project Counter CC&D capabilities in a CIGSS compliant architecture. Concept development studies and preliminary data collection experiments will be completed for FOPEN GMTI/ESM.

- AMSTE. ($ 14.805 Million)
  - A weapon system trade study of “higher-order” error terms and initial precision fire control tracking experiments will be completed. The study product will include an end-to-end operational system design, including identification of all system components, modifications required to existing systems, end-to-end concept of operations, and system performance analysis. Multisensor registration, association and tracking algorithms will be developed, and iterative experimentation will be conducted using simulated and real multi-sensor GMTI data. Two multi-sensor data collections will be conducted to provide data for tracker analysis and to investigate coordination difficulties associated with netted tracking. The design work to support real-time networked precision fire control experiments and demonstrations will begin. System developers will complete detailed definition of experiment system

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requirements and system design. Fabrication and procurement of long-lead system components, such as data links, sensor mode modifications, and precision fire control tracker real-time software development will commence. New technology development tasks will investigate techniques for using target signature data to improve track continuity and for automated management of sensor, weapons, and communications resources.

- Organic GMTI Radar (OGR). ($ 5.000 Million)
  - The Organic GMTI Radar (OGR) program will build and evaluate the brassboard proof-of-concept system. Additional data collection and propagation modeling efforts will lead to the selection of an operational frequency. Also, an experiment will be conducted using a HDTV transmitter. Planning for full scale testing and evaluation will begin.

(U) FY 2001 Plans:

- AVS. ($ 8.955 Million)
  - The Airborne Video Surveillance (AVS) program will integrate, demonstrate and evaluate extensively in laboratory systems and in some limited field experiments, airborne systems in simulated military missions with these technology goals: Precision Video Registration – demonstrate 2 meter RMS error geolocation accuracy on 90% of Class 1 and 80% of Class 2 imagery. Establish geolocation performance estimates over a wide array of global terrains for multiple algorithms.

- Counter CC&D. ($ 15.766 Million)
  - The Counter CC&D Program will conduct developmental flight tests to gather data on targets and backgrounds for algorithm training, and will perform validation flights to demonstrate that the system meets the target detection and false alarm requirements. The program will begin a yearlong phase of user demonstrations of the FOPEN SAR on the ARMY RC-12 that will be conducted with Army and Air Force exercises. Efforts will begin on rehosting MSET to SAIP residual for field demonstrations. FOPEN GMTI/ESM data analysis will be completed.

- AMSTE. ($ 29.000 Million)
  - Fabrication of new components and modifications of existing components of the field experiment system will be completed, including airborne sensors modified to support fire control, data links, ground processing with a real-time fire control tracker, and a weapon data link. A sequence of field experiments and demonstrations will be conducted to demonstrate and evaluate the capability to perform

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precision fire control targeting against moving targets. These experiments will culminate in a series of inert bomb drops on moving targets to demonstrate closed-loop weapon system precision. Field experimentation will be augmented with additional laboratory weapon system evaluations using data recorded during field experiments. Laboratory analyses will include investigation of various levels of sensor performance, use of a low-cost terminal guidance seeker, and extrapolation to operational systems. Advanced target track maintenance techniques developed in FY 2000 will be integrated into the precision fire control tracker and tested in the laboratory on recorded data to support subsequent AMSTE field experiments. Additional multiple platform GMTI data collections to support advanced GMTI precision fire control tracking will be conducted. Development of battle management tools will continue, and BM/C3 experiments will be planned with operational users.

- Organic GMTI Radar (OGR). ($ 4.000 Million)
  - The Organic GMTI Radar (OGR) program will complete the laboratory acceptance testing of hardware and software, and field experimentation will begin. Experiments will occur at multiple sites using bistatic modes with dedicated transmitters and transmitters of opportunity. Initial ROC curves will be developed and multistatic phenomenology will be verified. Also, the fabrication of a low-cost full-scale receive array will be initiated.

- Eyeball. ($ 1.985 Million)
  - Analyze data on E-O, IR, and radar to support concept feasibility and system requirements.
  - Establish sensor limits and primary trades; investigate novel concepts for cross-cued E-O, IR and radar systems.
  - Explore feasibility to exploit microdoppler target signature data for identification purposes.
  - Complete preliminary design of demonstration system.

- Real-Time Battle Damage Assessment (R/T BDA). ($ 6.500 Million)
  - Evaluate and/or develop RF algorithmic techniques and inexpensive weapon-mounted imagers to provide near real-time, all-weather assessment of precision weapons effects on high-value mobile threat targets.
  - Investigate RF techniques to exploit change detection to identify weapons-effects signatures in synchronized pre- and post-strike SAR imagery, and couple this signature assessment with real-time prediction of target functional degradation.
  - Precision munition “pop-off” BDA sensor preliminary designs will be conducted for a range of weapons.
  - Initiate data collection efforts.

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- Surface Target Identification for Engagement (STRIDE). ($ 8.000 Million)
  - Analyze a variety of electro-optical secondary identification deployment means including gun launching and deployment from towed decoy tubes.
  - Select candidates and begin preliminary designs.
  - Investigate novel RF object modeling technologies and unexplored phenomenologies such as wide dynamic range features and multi-look techniques. Optimum coupling of RF techniques with low-cost secondary identification will be determined.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Mar 00	Initial delivery of MSET MSI/SAR integrated tools.
Mar 00	AMSTE weapon system trade studies concluded.
Apr 00	OGR field experiment completed.
Jun 00	AMSTE multi-platform data collection.
Jun 00	Airborne demonstration of Airborne Video Surveillance technologies.
Jul 00	Preliminary flight demonstration of FOPEN radar on manned platform.
Jul 00	Completion of “brassboard” OGR receive antenna.
Jul 00	FOPEN GMTI/ESM concept development studies completed.
Sep 00	AMSTE real-time precision fire control laboratory experiment completed.
Sep 00	Design of AMSTE precision engagement demonstration system completed.
Sep 00	MSET integrated demonstration.
Sep 00	MSTAR demonstration of 25 different target types using full operational conditions and significant reduction in false alarm rates.
Sep 00	Completion of MSTAR Advanced Concepts evaluation.

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Oct 00	AVS precision video registration field experiments.
Jan 01	R/T BDA SAR imagery data collection.
Feb 01	Completion of Eyeball data collection plan, preliminary data analysis results.
Mar 01	AMSTE enhanced target maintenance laboratory experiment.
May 01	R/T BDA weapon deployed imager design completed.
May 01	STRIDE secondary identification preliminary designs begin.
Jun 01	Field testing of AMSTE precision fire control tracking software, sensor modes and data links completed.
Jul 01	OGR full system field demo.
Aug 01	Verification of FOPEN SAR automatic target detection and cueing.
Aug 01	STRIDE advanced RF technique evaluation completed.
Sep 01	MSET re-host to SAIP residual for field demonstrations.
Sep 01	User evaluation of FOPEN SAR operational utility.
Sep 01	AMSTE airborne precision fire control and engagement demonstration.
Sep 01	AVS field experiments for user evaluations and technology transition.
Oct 01	Completion of Eyeball preliminary design.

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COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	24.779	21.681	30.304	38.257	54.896	59.696	70.496	Continuing	Continuing
Advanced Ship-Sensor Systems, MRN-02	24.779	21.681	30.304	38.257	54.896	59.696	70.496	Continuing	Continuing

(U) Mission Description:

(U) The objective of the Marine Technology Program is to identify, develop, and rapidly mature critical advanced technologies and system concepts for maritime applications that support the following goals: 1) enhancement of the ability of US naval forces to interrogate and dominate the maritime battlespace, particularly in the littoral arena; 2) improved power projection capabilities of US naval forces, particularly with respect to their ability to influence the land battle; 3) advances in the ability of US naval assets to conduct operations as a seamlessly networked and integrated theater level force; and 4) maintenance of US naval force access to the littoral by countering the threat created by the worldwide spread of increasingly sophisticated technology. Proliferating threats such as modern cruise missile technology, commercially available overhead surveillance, advanced undersea mine capabilities, and modern, quiet diesel/electric submarines, pose major challenges for operations in the restricted water, near-shore regimes that are of growing importance to US strategic considerations, necessitating continued development of increasingly affordable far-term solutions for enhancing the operating capability and survivability margins of US naval forces in the littoral. This program element consists of a single project, Advanced Ship-Sensor Systems (MRN-02), comprised of the following programs: Undersea Littoral Warfare (ULW), Water Hammer, Buoyant Cable Array Antenna (BCAA), Robust Passive Sonar (RPS) and Future Submarine Payloads Program.

(U) The Undersea Littoral Warfare (ULW) program is developing the Netted Search, Acquisition, and Targeting (NetSAT) system, a networked approach for improved attack performance that exploits the use of a sonobouy field during the weapon run to identify, locate, and mitigate the impact of countermeasures and target evasion tactics on torpedo operation. A bi-directional fiber optic link enables return of torpedo information to a processor servicing the other sensors on the network in addition to providing a command link for the weapon. The ability to rapidly discern the geographic picture from multiple viewpoints is expected to provide major (10x) torpedo performance improvements in strong countermeasure environments while requiring only modest modification of existing torpedo inventories. Seamless coupling to a previously developed active acoustic search system (Distant Thunder) will provide significant enhancements at all points in the Anti-Submarine Warfare (ASW) attack chain. In addition, the ULW program is developing approaches to Synthetic Aperture Sonar (SAS) that would revolutionize our

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ability to classify and identify underwater mines and improve search rates more than an order of magnitude greater than is possible with current techniques. A comprehensive proof of performance demonstration will be conducted to assure readiness for transition to formal development programs.

(U) The Water Hammer program is conducting concept development for a standoff mine neutralization system consisting of a phased array of shock tubes to generate, focus, and transport to militarily important distances (tens of meters) a pressure pulse of sufficient energy to neutralize the threat (>1000 psi-msec; >2000 psi). Water Hammer has the potential for rapid, precision, in-stride lane clearance in deep or shallow water, reducing the need for high fidelity detection and classification. While the initial program focuses on mine/obstacle clearance, Water Hammer also has general utility as a close-in defense system for ships against multiple classes of subsurface threats.

(U) The Buoyant Cable Array Antenna (BCAA) program is developing an antenna capable of supporting full duplex (transmit and receive) connectivity for voice and data with communications satellites while floating on the ocean's surface. Towed behind a submarine, this capability will enable high quality, high data-rate connectivity with other military assets, even while operating at speed and depth. Supporting technologies to be developed include photonic signal and power links, enhanced antenna loading materials, processing algorithms for blind adaptive array calibration and washover mitigation, advanced communications protocols, and signature minimization techniques. In addition, the feasibility of related approaches to radio frequency (RF) communications at higher frequencies in a package physically remote from the actual submarine platform will be assessed.

(U) The Robust Passive Sonar (RPS) program is an outgrowth of the successful experiments performed under the ULW program. The RPS program will investigate the ability of innovative, optimal processing approaches, coupled as appropriate to multi-dimensional receive arrays and/or external information, to precisely cancel the acoustic interference generated by surface shipping. At the lower frequencies that increasingly dominate submarine detection by acoustic means, shipping interference represents the primary noise background limiting the performance of existing sonar systems; this is especially true in the dense shipping environment typical of many littoral areas. Precise notching of shipping interference could result in net system performance gains of 10-20 dB, and the means of accomplishing it are expected to dictate preferred future array and acoustic sensor field designs. A data-driven program of algorithmic development and performance demonstration will be conducted as a multi-disciplinary effort. Participation across a broad spectrum of organizations in close coordination with Navy resources and organizations is intended.

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(U) Investigations into advanced Friction Drag Reductions Techniques will be conducted under this project. The goal is to increase the overall efficiency of surface and sub-surface naval vessels by reducing the friction drag on the structure surface created by the flow of water over the structure. Polymers and water bubble technologies are of particular interest. Scalable modeling of the turbulent flow will be conducted by taking advantage of advanced computing techniques.

(U) The Future Submarine Payloads Program will continue to build upon the concepts generated under the Sub Payloads and Sensors program (PE 0602702E, Project TT-03). Mature and promising concepts will be further developed to expand the effectiveness and lethality of US submarine platforms.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Undersea Littoral Warfare (ULW). ($ 17.638 Million)
  - Completed initial prototype NetSAT system, integrating weapons control with countermeasures deconfliction.
  - Conducted laboratory testing to establish initial detection-to-attack performance enhancements provided by networked approaches.
  - Conducted engineering checkout of networked NetSAT hardware suite.
  - Conducted technical field testing of NetSAT prototype against submarine target.
  - Completed feasibility investigation of the Robust Passive Sonar processing and array concepts, utilizing geographically referenced processing and space-time processing (STP) techniques.

- Water Hammer. ($ 3.526 Million)
  - Continued non-explosive underwater energy projection technology development for mine neutralization, including fabrication and component testing for 4x4 source array test article.

- Buoyant Cable Array Antenna (BCAA). ($ 3.615 Million)
  - Conducted comparative testing of DARPA-generated BCAA concept and Navy-generated single element approaches in Ultra High Frequency (UHF) band; assessed cost/performance tradeoffs of differing approaches.

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(U) FY 2000 Plans:

- Undersea Littoral Warfare (ULW). ($ 16.951 Million)
  - Update and complete development of prototype NetSAT system.
  - Conduct NetSAT follow-on technical demonstration, emphasizing endgame coordination with existing systems for final target updates.
  - Integrate end-to-end SAS processing chain in laboratory; commence development of advanced mine classification algorithms.
  - Commence integration of SAS testbed for proof of performance testing.
  - Assess potential Robust Passive Sonar (RPS) performance improvements in passive sonar from exploitation of external information (overhead surveillance and acoustic monitors).
  - Commence RPS development of space-time processing algorithms for advanced surface shipping interference rejection.

- Buoyant Cable Array Antenna (BCAA). ($ 3.980 Million)
  - Conduct component technology risk reduction and maturation.
  - Initiate design and development of a full duplex (transmit/receive) submarine BCAA prototype antenna; conduct preliminary design review.
  - Conduct risk mitigation testing of transmit link technologies.

- Water Hammer. ($ 0.750 Million)
  - Complete 4x4 source array and test subsystem.
  - Validate nonlinear numerical model from test results.

(U) FY 2001 Plans:

- Undersea Littoral Warfare (ULW). ($ 20.959 Million)
  - Conduct final NetSAT operational demonstration.
  - Coordinate transition of NetSAT technologies to Navy.
  - Conduct Synthetic Aperture Sonar (SAS) data collection exercises; complete SAS classification performance assessment.

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- Coordinate transition of Robust Passive Sonar technologies to Navy.
- Continue development of space-time processing algorithms for advanced surface shipping interference rejection.
- Conduct initial Robust Passive Sonar data collection field exercises.
- Create baseline integrated Robust Passive Sonar interference rejection processing stream; conduct preliminary performance assessment.

- Bouyant Cable Array Antenna (BCAA). ($ 5.345 Million)
  - Complete algorithm and software development for space-time adaptive communications link processor.
  - Complete design of BCAA prototype antenna; conduct critical design review.
  - Fabricate BCAA prototype antenna; commence integration with submarine deployment and retrieval systems.
  - Assess feasibility of remotely operated antenna concepts for improving submarine stealth while providing round-the-clock two-way communications.

- Future Submarine Payloads Program. ($ 4.000 Million)
  - Conduct structural, material, and architectural trade studies to allow storage and launch of existing payloads in an underwater environment.
  - Commence conceptual designs for the underwater launch and recovery of future submarine payloads

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	23.659	22.538	21.964
Current Budget	24.779	21.681	30.304

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(U) Change Summary Explanation:

FY 1999	Increase reflects minor repricing and completion of Anti-Submarine Warfare Netted Search, Acquisition and Targeting (NetSAT) effort.
FY 2000	Decrease reflects repricing of the Buoyant Cable array program and a government-wide rescission offset by a Congressional increase for the Water Hammer effort.
FY 2001	Increase reflects emphasis on the advanced technology associated with the development of hydrodynamic friction reduction and turbulant flow scalable models.

(U) Other Program Funding Summary Cost:

Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Undersea Littoral Warfare (ULW):	
Jul 00	Conduct follow-on technical demonstration of prototype NetSAT system in a controlled test range environment
Dec 00	Initial end-to-end SAS processing chain complete.
Jun 01	Conduct sensor-to-shooter operational demonstration including surveillance detection, handoff, targeting and attack in a countermeasure environment.
Sep 01	SAS classification performance assessment complete.
Water Hammer:	
Sep 00	Complete 4 x 4 Water Hammer source array and test subsystem.
Buoyant Cable Array Antenna (BCAA):	
Jun 00	Conduct Preliminary Design Review (PDR) for BCAA prototype system.

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Mar 01	Conduct Critical Design Review (CDR) for BCAA prototype system.
Mar 01	Conduct feasibility assessment for remotely operated submarine communications concepts.
Nov 01	BCAA multi-element antenna prototype system complete.

Robust Passive Sonar (RPS):

Mar 00	Exploitation of external information feasibility assessment complete.
Mar 01	Initial RPS data collection field exercise complete.
Jun 01	Baseline interference rejection processing stream for passive sonar created.
Sep 01	Preliminary RPS performance assessment complete.

Friction Drag Reduction Techniques:

Jun 01	Initiate effort to exploit results from PE0601101E (Project MS-01) Fast Ship effort to Naval/sea lift fleets
Sep 01	Design near full-scale test to demonstrate efficiency improvement.

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COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	85.287	96.320	134.249	157.667	161.100	136.000	87.000	Continuing	Continuing
Rapid Strike Force Technology LNW-01	43.870	52.955	38.129	19.992	6.500	32.500	27.000	Continuing	Continuing
Small Unit Operations LNW-02	41.417	43.365	35.120	47.675	32.600	41.500	45.000	Continuing	Continuing
Future Combat Systems LNW-03	0.000	0.000	61.000	90.000	122.000	62.000	15.000	Continuing	Continuing

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Three broad efforts are being pursued in support of this objective: Rapid Strike Force Technology, Small Unit Operations and Future Combat Systems.

(U) The Rapid Strike Force Technology project is developing the technologies necessary for highly mobile, covert transportation and information gathering systems to enhance U.S. early-entry capabilities. The primary thrusts of this project include: 1) the Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program that will design, develop, test and transition a minimum of four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles to the Services; 2) the Solar Blind Detectors program that will develop technologies to enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles; 3) the Tactical Mobile Robotics (TMR) program that will develop mobile robotic technologies that will enable land forces to dominate battlespace using individual, or teams, of mobile robots in complex terrain; 4) the Mobile Tactical Operation Center/Future Ground Combat System program that will explore and develop technologies to be used by tactical commanders in situational awareness, communications and control; and 5) the Metal Storm program that will develop a system to pack, transport and fire at variable sequence rates.

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(U) The goal of the Small Unit Operations project is to develop critical technologies that will enable dispersed units to effectively perform warfighting operations traditionally requiring massed forces. Technology development efforts will focus on a comprehensive awareness capability that provides real-time, essential information for small units and individual warfighters; wireless communication technologies to permit exchange of voice, digital and video data with other systems; geolocation technologies that provide navigation information in built-up, forested and mountainous environments; internetted tactical surveillance and targeting sensors to complement information requirements not satisfied by national, theater and component sensor programs; and automated ultra-miniature imaging and non-imaging sensors.

(U) The Future Combat Systems project goal is to develop the optimal balance among critical performance factors, including ground platform strategic, operational and tactical mobility, lethality, survivability and sustainability. Efforts will focus on creating a multi-functional, multi-mission, re-configurable group of systems that maximize joint interoperability, strategic transportability and commonality of mission roles. Support programs will develop rapid response and lethality packages requiring fewer personnel, decreased logistical support and lower life-cycle costs while increasing survivability.

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	88.613	97.825	101.376
Current Budget	85.287	96.320	134.249

(U) Change Summary Explanation:

FY 1999	Decrease reflects SBIR and other minor below threshold reprogrammings.
FY 2000	Decrease reflects congressional reduction to Mobile Theater Operations Center and government-wide rescission, partially offset by below threshold reprogramming for Tatical Sensors.
FY 2001	Increase reflects establishment of the new Future Combat Systems project. This add is partially offset by a reduction in scope of the Situational Awareness System program in the Small Unit Operations project.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Rapid Strike Force Technology LNW-01	43.870	52.955	38.129	19.992	6.500	32.500	27.000	Continuing	Continuing

(U) Mission Description:

(U) The emerging US vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient, land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance, which are important aspects of an early-entry capability. The project consists of: Combat Hybrid Power Systems (CHPS); Reconnaissance, Surveillance and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Solar Blind Detectors; Metal Storm (MS); and a Future Ground Combat System that will include a Mobile Tactical Operations Center (M-TOC). The CHPS, RST-V, M-TOC and TMR programs are closely coordinated with the US Army, Navy and Marine Corps, and with DARPA's Small Unit Operations (LNW-02) project.

(U) The Combat Hybrid Power System program will develop enabling technologies and conduct demonstrations of an integrated hybrid electric power system that provides power and energy management for all of the electric subsystems throughout future combat vehicles. Hybrid electric power is an essential enabling technology for future combat vehicles given the number of electrically powered subsystems planned for implementation. The hybrid electric power system will consist of an engine/alternator, sized for average power demand, energy storage and power averaging components that provide both continuous and pulsed power, distribution networks, subsystem controls and power conditioning devices. Vehicles of various configurations and for a variety of missions will be simulated to evaluate subsystem requirements, topologies and military utility. The simulated vehicle concepts will demonstrate greatly reduced noise and thermal signatures; improved mobility, survivability, lethality and fuel economy; optimized interior layouts; significantly reduced volume and weight. These advantages will result in deployable, affordable combat vehicles that meet mission requirements.

(U) The Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate and transition to the Services four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in the areas of integrated survivability techniques and advanced suspension, including both active and passive approaches. The vehicle will also host integrated precision geolocation, communication and Reconnaissance, Surveillance and Targeting (RST) sensor subsystems. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators and special reconnaissance forces. Critical

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components and technologies include a high efficiency, reduced signature hybrid electric propulsion system with increased fuel economy; an advanced suspension to increase cross-country speed and provide platform stabilization; an advanced integrated survivability suite; and the capability to operate in either a silent watch/silent movement or mechanical mode. The vehicle will incorporate modularized design components to allow for signature management and rapid reconfiguration for mission tailoring and multiple purpose utility. Hardware and lessons learned from this program directly support the Marine Corps-Navy Extending the Littoral Battlespace (ELB) ATD as well as address joint US Marine Corps – Special Operations Command (USMC-SOCOM) requirements for the Internally Transportable Vehicle/Light Strike Vehicle (ITV/LSV) and Tactical Vehicle, Reconnaissance, Surveillance, Targeting and Acquisition (TV-RSTA) program and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) upgrades. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs) (e.g. Capable Warrior).

(U) The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate the battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR will provide DoD organizations with semi-intelligent, cooperating platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis is on urban environments and denied areas. Specific robot technologies that will be advanced include: perception, autonomous operation and advanced locomotion for complex obstacle negotiation. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90 percent accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction and (b) traversal of rugged/complex terrain using 1 command per 100m of travel. Locomotion capabilities will feature portable (sub-meter-scale) vehicles traveling up to 1 m/s over 25 cm steps and decimeter-scale rubble.

(U) The Solar Blind Detectors program (formerly titled "Vehicle Self-Protection") will develop an ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) The Future Combat Systems (FCS) program, an out-growth of the Mobile Tactical Operations Center, will develop network centric concepts for a multi-mission combat system (MMCS) that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly

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survivable in combat through the use of integrated command and control capabilities with unsurpassed situational understanding for all levels of commanders. This system will be transitioned to the U.S. Army for full development and ultimate deployment in the 2012 timeframe. The Future Combat Systems (FCS) will be a multi-functional, multi-mission re-configurable system of systems to maximize joint inter-operability, strategic transportability and commonality of mission roles including direct and indirect fire, air defense, reconnaissance, troop transport, counter mobility, non-lethal and C2 on the move. The goal of this effort is to develop a network centric advanced force structure, quantify its benefits and identify materiel solutions and technologies within the context of that force. It will also identify Doctrine, Operational, Training, Leader and Material (DOTLM) specific changes necessary as a result of the development of this network centric advanced force structure. In FY 2001, the FCS program will be funded from a new Project, LNW-03, entitled Future Combat Systems, still within Program Element 0603764E.

(U) The Metal Storm (MS) program will develop a unique 100 percent solid state system for tightly packing, storing, transporting and firing projectiles in multiple tubes with high or low pressures, in an electronically infinitely variable sequence rate with applications to small arms and crew served weapons. The program facilitates current US force reduction and restructuring policies while increasing firepower. The program will demonstrate revolutionary in weapon designs and applications that will far exceed the effectiveness and versatility of existing small arms and large munitions weaponry and will primarily focus on developing, fabricating and testing two 7.62 mm sniper rifle prototypes for Special Operations Forces use. The design will incorporate a multi-barrel configuration allowing instant access to a variety of projectiles. Studies will be conducted to optimize propellants and projectiles; to examine electronic keying, silencing and underwater operations; and to investigate the physics of scaling from a small caliber, low pressure design to a large caliber (40 and 81mm), modest barrel pressure (~60,000 psi) design. Through a Project Arrangement under the Deutsch Ayers Agreement between the US and Australia, the Defence Science & Technology Office (DSTO) will perform work in the areas of scaling, modeling and simulation, and small arms live fire testing.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Combat Hybrid Power Systems (CHPS). ($ 16.285 Million)
  - Installed and integrated hybrid electric power components in the Systems Integration Laboratory (SIL).
  - Conducted tests that demonstrated simultaneous operation of pulsed and continuous loads in the laboratory and verified virtual prototype models for selected components.

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- Completed design and initiated fabrication of advanced, high-risk power system components (critical enabling technologies) in particular, Lithium Ion batteries and Silicon Carbide based power electronics module.
- Demonstrated hardware-in-the-loop virtual prototype.

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 6.068 Million)
  - Completed Critical Design and conducted Critical Design Review of both RST-V team designs.
  - Down selected to one contractor.
  - Finalized design and conducted Fabrication Readiness Review.
  - Refined development of automotive subsystems.
  - Evaluated emerging technologies for high data rate covert communications.

- Tactical Mobile Robotics (TMR). ($ 16.254 Million)
  - Refined advanced employment concepts to exploit portable robot potential and accommodate expanded user interest.
  - Demonstrated breadboard robot perception, autonomy and obstacle negotiation (stair climbing) in challenging mission scenarios.
  - Completed and evaluated competing designs for integrated robotic system.
  - Refined system design and employment plans to exploit progress made with enabling technologies and accommodated multiple collaborating platform employment where practical.
  - Evaluated advanced communication and control techniques.

- Solar Blind Detectors Program. ($ 4.263 Million)
  - Initiated development of an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

- Advanced Concepts Evaluation. ($ 1.000 Million)
  - Conducted technology assessment and feasibility testing of advanced rapid strike force concepts in the areas of battlefield communications and asset control, autonomous systems, fire support and situational awareness.

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(U) **FY 2000 Plans:**

- Combat Hybrid Power Systems (CHPS). ($ 10.222 Million) [Future Combat Systems – related = $10.222 Million]
  - Install the completed, advanced, high-risk hybrid electric power system components in the Systems Integration Laboratory (SIL).
  - Continue test and evaluation of integrated hybrid electric power system and subsystems.
  - Investigate and quantify benefits of hybrid electric power for future combat vehicles using SIL and virtual prototype.
  - Continue development of and exercising the vehicle virtual prototype.
  - Investigate alternative critical power system component technologies.
  - Develop coordinated plan for continued effective utilization of CHPS SIL and virtual prototypes.
  - Transition CHPS program to U.S. Army Tank-Automotive and Armaments Command (TACOM).

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 11.237 Million)
  - Perform wheelmotor qualification tests.
  - Roll out vehicles 1 and 2.

- Tactical Mobile Robotics (TMR). ($ 15.633 Million)
  - Initiate development of fully functional tactical robotic platforms.
  - Integrate enabling technologies into functional platforms.
  - Refine demonstration and transition plans commensurate with success in system design and multi-platform collaboration.

- Solar Blind Detectors Program. ($ 5.895 Million)
  - Demonstrate low defect epitaxial material compatible for photodetectors with high sensitivity operating in the solar-blind region of the spectrum (240-300 nm).

- Future Combat Systems (FCS). (Formerly Mobile Tactical Operations Center (M-TOC). ($ 6.984 Million)
  - Initiate concept design development.
  - Begin formulation of force level concepts.
  - Initiate development standard threat scenarios and Integrated Development Environment (IDE).

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- Perform independent validation, verification and accreditation effort.

- Advanced Concepts Evaluation. ($ 2.984 Million)
  - Conduct technology assessment and feasibility testing of advanced rapid strike force concepts including precision guided munitions, force-on-force modeling, counter situational awareness, covert autonomous sensors and future unmanned vehicle systems.
  - Conduct studies to optimize the Metal Storm concept, research propellants and projectiles, and develop approaches to enhance accuracy. Establish international agreement between the United States and Australia.

(U) FY 2001 Plans:

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 8.796 Million)
  - Deliver vehicles 1 and 2 for participation in US Marine Corps (USMC) Advanced Warfighting Experiment.
  - Integrate and demonstrate Survivability Suite.
  - Deliver vehicles 3 and 4.
  - Evaluate active suspension enhancement of RST-V.

- Tactical Mobile Robotics (TMR). ($ 12.217 Million)
  - Complete integrated robotic system development and testing.
  - Conduct operational demonstrations with integrated systems.
  - Initiate transition to military departments.

- Solar Blind Detectors Program. ($ 5.338 Million)
  - Demonstrate solar-blind detector array with 128 x 128 pixels.

- Metal Storm (MS). ($ 10.778 Million)
  - Finalize designs for main sniper rifle and targeting and electronic subsystems.
  - Demonstrate a single barrel, high rate of fire, electronic sniper rifle.
  - Perform modeling studies of lethality and penetration requirements.

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– Perform scaling analysis of Metal Storm technology to larger calibers.

- Advanced Concept Evaluation. ($ 1.000 Million)
  – Continue technology assessment and feasibility testing of advanced rapid strike force concepts including all electric and ceramic engine systems, thin film batteries and future unmanned vehicle systems.

(U) Other Program Funding Summary Cost: *(In Millions)*

	FY1999	FY2000	FY2001
PE 0603640M Marine Corps Advanced Technology Demonstration	3.300	0.700	0.500
PE 0602601A Combat Vehicle and Automotive Technology	0.000	6.586	0.000
PE 0603005A Combat Vehicle and Automotive Advanced Technology	0.500	10.012	4.700

(U) Schedule Profile :

Plan	Milestones
Jan 00	TMR: Conduct preliminary design reviews and begin fabrication of selected TMR platforms.
Feb 00	RST-V: Vehicle 1 rollout.
Mar 00	FCS: Initiate Integrated Development Environment (IDE) effort.
Mar 00	FCS: Initiate technology investment activities.
May 00	FCS: Initiate concept design development.
Jul 00	CHPS: Integrate advanced components and demonstrate fully integrated combat hybrid power system laboratory.
Jul 00	TMR: Conduct final technology demonstration and critical design review for selected TMR platforms.
Sep 00	FCS: Technology investment review.
Sep 00	CHPS: Configure system for Service transition.
Oct 00	RST-V: Deliver vehicles 1 and 2.
Mar 01	Demonstrate RST-V system capabilities in Advanced Warfighting Experiment (AWE).
Mar 01	Solar Blind Detectors: Demonstrate Avalanche Photo Detector (APD) array with 100 amps/watt responsity and low dark current.

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Apr 01	MS: Complete physics of scaling study.
Jun 01	RST-V: Integrated Survivability demonstration of Reconnaissance, Surveillance, and Targeting Vehicle (RST-V).
Jul 01	TMR: Complete operational demonstrations of Tactical Mobile Robotic systems. Initiate transition and technology transfer plans.
Dec 01	MS: Firing demonstration of single barrel, high rate of fire, electronic sniper rifle.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Small Unit Operations LNW-02	41.417	43.365	35.120	47.675	32.600	41.500	45.000	Continuing	Continuing

(U) Mission Description:

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) Superb situational awareness is critical to the combat effectiveness and survivability of such forces. Each small team must constantly know where it is, where the other teams are and where the enemy and any other threats are located. The Services are developing lightweight radio communications and Global Positioning System (GPS) dependent geo-positioning systems packaged into fielded capabilities such as the Land Warrior System. In addition, advanced standoff sensor systems such as Predator, Global Hawk and Discoverer II are being developed to monitor the enemy's movements and characterize the battlespace. These capabilities will greatly improve the combat effectiveness of small dismounted forces, but will be limited to operations in open areas under benign conditions. Current communications, navigation and sensor technologies are poorly configured to operate in urban areas (outside or inside buildings), in jungles, forests or mountainous terrain. Communications technology is susceptible to enemy jamming or unintentional radio interference and are not covert to intelligence operations. Extant sensors and exploitation capabilities are limited to broad area surveillance of vehicles and facilities; data is not mined and distributed to forces at the lowest echelon.

(U) The objective of the Small Unit Operations Project is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated fusion and mining of information sources to provide a “bubble” of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and ad hoc networked communications that “glue” the components together, operate in any environment, are covert and resistant to interference. In addition, these technologies must not significantly increase the dismounted force’s mass and power burden. The programs that make up this project include the Situational Awareness System (SAS), Tactical Sensors, Advanced Sensing Technologies, Optical Tags and Wolfpack.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02

(U) The Situational Awareness System (SAS) will integrate these technologies into a 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The Agency module will be interoperable with the Army Land Warrior equipment and provide much greater functionality at significantly less weight. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. This program will investigate the critical SAS performance parameters with in-depth experiments. It will provide user-centered design input for developers and provide an independent assessment of the SAS design. The experiments will be focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested and mountainous terrain. It will also acquire and codify knowledge of dispersed land force tactics to develop decision aids and evaluate the utility of the aids for small units. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the SAS functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises to provide independent validation of the SAS functionality.

(U) The Tactical Sensors program will develop new sensor system technologies that will provide the warfighter with a capability to detect, track and classify mobile tactical targets, and to characterize fixed, man-made structures. These sensor systems provide a local, in-situ sensing capability near high value targets or at choke points in denied areas. Information provided by these sensors can be fused with other longer-range space, airborne and ground sensor systems to enhance the aggregate surveillance and tracking capabilities of US forces. Applications include surveillance, cueing, precision targeting, intelligence and battle damage assessment with respect to time critical, mobile targets (vehicles and humans) and to fixed man-made structures (surface and underground facilities).

(U) The Advanced Sensing Technologies program will develop a completely new class of sensors for military surveillance and targeting applications. These sensors will provide surveillance, target detection, tracking, classification, cueing and bomb damage assessments at distances much greater than current capabilities. The sensors will use recent technical breakthroughs to permit vulnerability and access to the target signatures.

(U) The Optical Tags Program will investigate nonlinear optical technologies and innovative design and fabrication techniques for kilometer-range optical tag systems, which provide a quantum leap in tactics and operations in a wide variety of applications. The Optical Tags Program will develop validated models to predict system performance in support of a selected set of applications for technology demonstration. The program will select a relatively mature application, such as marking or tagging, and a relatively immature application, such as precision strike. The applications

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will be selected based on their operational significance and user input. The Optical Tags Program will perform system engineering to develop systems performance requirements for the applications and will demonstrate the systems in meaningful warfighter experiments.

(U) The Wolfpack Program will develop technologies that would enable the U.S. to deny the enemy use of radio communications throughout the battlespace. This will culminate in a networked system of air emplaced, autonomous, ground-based monitors/jammers linked together to cooperate and avoid disruption of friendly military and protected commercial radio communications. The specific technologies to be developed include: (1) high efficiency sub-resonant antennas, (2) networking algorithms to allow coordinated access to the spectrum by communicators, jammers and SIGINT systems, (3) methods to easily deploy the systems high terrain high points, and (4) algorithms to rapidly and autonomously detect, classify, identify and jam target signals with low power electronics.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Situational Awareness System (SAS). ($ 27.235 Million)
  - Assessed advanced concepts and technologies for dispersed land forces applications.
  - Completed developments for the situation awareness and real time tasking and control technologies.
  - Completed technology development for tactical communications capability.
  - Completed evaluation of enabling technologies associated with SAS design and conducted breadboard demonstration of critical communications and geolocation technologies.
  - Completed detailed design of SAS and began development of situational awareness brassboard system.

- Tactical Sensors. ($ 13.124 Million)
  - Continued development of internetted remote control sensors to detect, localize and characterize targets.
  - Continued development of surveillance and targeting sensors systems for dispersed operations.

- Advanced Sensing Technologies. ($ 1.058 Million)
  - Established feasibility of concept.
  - Initiated development of a breadboard sensor.

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(U) FY 2000 Plans:

- Situational Awareness System. ($ 31.880 Million) [Future Combat Systems – related = $17.900 Million]
  - Complete development of the Individual Warfighter Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA)-Base, WTA Mobile and Relay/Router/Beacon detailed hardware design, software modules and network protocols.
  - Complete Individual Warfighter/WTA software coding.
  - Complete IWSAS, WTA-Base, WTA-Mobile, Relays and network code development and testing.
  - Complete situation awareness (planning, tasking, sensor control, navigation and alerts) application software coding and testing.
  - Complete brassboard fabrication of the major SAS elements (IWSAS, WTA and Relays).
  - Conduct performance assessment of Phase 3 brassboard design.
  - Verify that Individual Warfighting Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99 percent service availability objective.
  - Verify geolocation accuracy and navigation performance in urban and field environments.
  - Develop Wolfpack system architecture and conduct system level trades to develop sub-system requirements.
  - Determine the optimum use of legacy systems for IPB and cueing and potential modifications required for coordinated spectrum access.

- Tactical Sensors. ($ 8.561 Million)
  - Continue development of internetted remote control sensors to detect, localize and characterize targets.
  - Continue development of surveillance and targeting sensors systems for dispersed operations.
  - Conduct technology development for a kilometer-range optical tag system.
  - Select a relatively mature application and develop optical tag requirements.
  - Select a relatively immature application and develop contractor team.

- Advanced Sensing Technologies. ($ 2.924 Million)
  - Complete and test breadboard sensor and initiate brassboard development.

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(U) FY 2001 Plans:

- Situational Awareness System. ($ 13.344 Million)
  - Complete fabrication of Individual Warfighting System Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) Mobile and Base, tactical sensors and tactical relays for test.
  - Integrate IWSAS, WTA-Mobile and Base with external legacy communications, data and sensor equipment.
  - Test integrated system and conduct performance assessment of final Phase 3 design; measure IWSAS, WTA and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99 percent service availability objective.
  - Complete development of detailed demonstration scenarios to test and evaluate performance under operational conditions.
  - Perform setup of field demonstration.
  - Develop training materials and conduct soldier training for field demonstration.

- Tactical Sensors. ($ 7.944 Million)
  - Continue development of internetted remote control sensors to detect, localize and characterize targets.
  - Continue development of surveillance and targeting sensors systems for dispersed operations.

- Optical Tags. ($ 4.944 Million)
  - Demonstrate a kilometer-range optical tag system.
  - Predict tag performance for relatively mature application.
  - Develop requirements and predict tag performance for relatively immature applications.

- Advanced Sensing Technologies. ($ 2.944 Million)
  - Complete brassboard and initiate fieldable sensor development.

- Wolfpack. ($ 5.944 Million)
  - Complete system design and performance analysis.
  - Conduct proof-of-concept demonstrations of high-speed signal detection and identification algorithms.
  - Verify low duty cycle, low power jamming techniques with benchtop experiments.

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(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile :

Plan	Milestones
Situational Awareness System:	
Feb 00	Complete SAS critical design review.
May 00	Complete SAS software coding.
Jun 00	Complete SAS sensor and weapon simulation.
Jul 00	Complete brassboard SAS integration and test.
Mar 01	SAS components fabricated.
Tactical Sensors:	
May 00	Demonstrate Miniature Infrared Camera (MIRC).
Aug 00	Demonstrate brassboard integrated micro-(UGS) system.
Sep 01	Complete micro-UGS field demonstration tests.
Optical Tags:	
Mar 01	Mature application performance predicted.
Jun 01	Less mature application requirements developed and performance predicted.
Advanced Sensing Technologies:	
Sep 00	Demonstrate final breadboard.
Sep 01	Demonstrate final brassboard.

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Wolfpack:

Mar 01	Initial enabling technology demonstrations.
Jun 01	Single sensor performance verified in laboratory.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Future Combat Systems LNW-03	0.000	0.000	61.000	90.000	122.000	62.000	15.000	Continuing	Continuing

(U) Mission Description:

(U) The U.S. Military requires flexible, effective and efficient multi-mission forces capable of projecting overwhelming military power worldwide. This force must ultimately provide our national leaders with increased options when responding to potential crises and conflicts. To satisfy this requirement, the joint Army/DARPA Future Combat System (FCS) program has been developed to provide enhancements in land force lethality, protection, mobility, deployability, sustainability, and command and control capabilities.

(U) The FCS program will develop network centric concepts for a multi-mission combat system that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable in combat through the use of integrated command and control capabilities with unsurpassed situational understanding for all levels of commanders. The goal of the FCS project is to strike an optimum balance between critical performance factors, including ground platform strategic, operational and tactical mobility; lethality; survivability; and sustainability. The Defense Advanced Research Projects Agency (DARPA) has worked to develop technologies to counter adversaries' modern tank forces with man carried missiles and unmanned indirect fire missile systems. The success of these efforts enables consideration of a modern, light force that does not rely solely on a heavy armor based force structure. The DARPA studies have identified key areas for technology development to enhance these capabilities in a future force as: networked Command, Control, and Communications, Computers, Intelligence, Surveillance, and Targeting (C4IST); robotics; precision indirect fires; and beyond line of sight (BLOS) organic sensing and precision all-weather surveillance and targeting system.

(U) The FCS system will transition to the U.S. Army for full development and ultimate deployment in the 2012 timeframe. The Future Combat System will be a multi-functional, multi-mission re-configurable group of systems to maximize joint inter-operability, strategic transportability and commonality of mission roles including direct and indirect fire, air defense, reconnaissance, troop transport, counter mobility, non-lethal, and C2 on the move. As a result, this effort will develop a network centric advanced force structure, quantify its benefits and identify material solutions and technologies within the context of that force. It will also identify Doctrine, Operational, Training, Leader and Material (DOTLM) specific changes necessary as a result of the development of this network centric advanced force structure. This program was funded in FY 2000 from Project LNW-01, Rapid Strike Force Technology, within this same Program Element.

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(U) The Advanced Fire Support Systems (AFSS) program will develop and test a containerized, platform-independent multi-mission weapon concept. These systems will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support and lower life-cycle costs, while increasing survivability compared to current gun and missile artillery. AFSS will allow the military to capitalize on recent advances in military doctrine and infrastructure, such as the ongoing digitization of the Army. It will also allow the Army to streamline its missile acquisition plan around future common missiles. The program will develop and demonstrate highly flexible systems including a modular, multi-mission precision missile, a remotely commanded self-locating launcher, and a command and control system compatible military doctrine. The Advanced Fire Support System will be a key element supporting beyond line of sight engagements for Future Combat Systems. The AFSS program was funded in FY 2000 from Project TT-04, Advanced Land Systems Technology, in Program Element 0602702E.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

(U) FY 2000 Plans:

- Not Applicable.

(U) FY 2001 Plans:

- Future Combat Systems (FCS). ($ 49.000 Million)
  - Complete concept designs.
  - Conduct experiments to validate modeling and simulation tool set and confirm analytic results of designs and studies.
  - Technology assessments of robotics, unmanned ground vehicles, maneuver C3, organic all-weather targeting vehicle and all-weather surveillance and targeting sensor.
  - Maneuver Beyond Line of Sight (BLOS)/Networked Fires Weapon. Complete system hardware and software developments and limited objective flight tests. Plan and initiate preparations for full scale demonstration.

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- Advanced Fire Support Systems (AFSS). ($ 11.000 Million)
  - Continue system hardware and software development.
  - Complete limited objective flight tests.
  - Plan and initiate preparations for full system demonstrations.

- Advanced Concepts. ($ 1.000 Million)
  - Explore new enabling technologies for unmanned systems and sensor technologies required for unmanned systems.

(U) **Other Program Funding Summary Cost:** *(In Millions)*

		FY1999	FY2000	FY2001
PE 0602601A	Combat Vehicle and Automotive Technology	0.000	0.000	7.752
PE 0603005A	Combat Vehicle and Automotive Advanced Technology	0.000	0.000	35.789

(U) **Schedule Profile:**

Plan	Milestones
Oct 00	Advanced Fire Support Systems AFSS critical design review.
Feb 01	AFSS first limited objective tests.
May 01	FCS risk reduction independent design review (IDR).
Oct 01	AFSS first guided test.
Jan 02	FCS risk reduction IDR 2.
Mar 02	AFSS first terminally guided test.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support				R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, R-1 #123					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	32.898	32.103	34.679	35.954	37.276	38.400	38.542	Continuing	Continuing
Management Headquarters (R&D) MH-01	32.898	32.103	34.679	35.954	37.276	38.400	38.542	Continuing	Continuing

(U) Mission Description:

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical and information security, travel, supplies and equipment, communications, printing and reproduction. In addition, funds are included for reimbursing the military services for administrative support costs associated with contracts undertaken on the agency's behalf.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Management Headquarters. ($ 32.898 Million)
  - DARPA continued to fund management and administrative support costs. In FY 1999, salary requirements for Intergovernmental Personal Act (IPA) appointments were moved to program funds in lieu of being centrally funded in this program element. The FY 1999 additional salary requirements associated with DARPA's expanded hiring authority (Section 1101 of the FY 1999 Authorization Act) partially offset the IPA salary transfer.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters PE 0605898E, R-1 #123

(U) FY 2000 Plans:

- Management Headquarters. ($ 32.103 Million)
  - DARPA will continue to fund civilian direct-hires and administrative support service costs. Salary reimbursement for IPAs remains funded with program funds in keeping with OMB policy. Reductions associated with this change have been substantially offset by the additional costs of the Section 1101 experimental hiring program.

(U) FY 2001 Plans:

- Management Headquarters. ($ 34.679 Million)
  - DARPA will continue to fund civilian direct-hires, both career and Section 1101 employees, and administrative support costs. Expanded Departmental and Federal physical and information security requirements and anticipated pay raise requirements are also funded.

(U) Program Change Summary: (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	38.498	31.387	32.632
Current Budget	32.898	32.103	34.679

(U) Change Summary Explanation:

FY 1999	Decrease reflects removal of IPA costs from this PE to program funds, partially offset by the increased salary requirements of the Section 1101 hiring authority.
FY 2000	Increase reflects mandated pay raises and additional security requirements, partially offset by the government-wide rescission.
FY 2001	Increase reflects mandated pay raises and additional security requirements.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA66 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, R-1 #123

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.