RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, R-1 #45

COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	213.379	199.564	150.400	148.070	143.776	143.492	143.211	Continuing	Continuing
Uncooled Integrated Sensors MT-03	12.776	6.441	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Electronic Module Technology MT-04	38.963	35.000	21.699	31.807	29.747	29.688	29.630	Continuing	Continuing
Centers of Excellence MT-07	5.213	5.000	4.000	0.000	0.000	0.000	0.000	0.000	N/A
Advanced Lithography MT-10	54.457	36.632	25.000	25.000	25.000	0.000	0.000	0.000	N/A
MEMS and Integrated Micro-systems Technology MT-12	46.730	40.783	28.000	19.804	19.725	19.792	19.753	Continuing	Continuing
Mixed Technology Integration MT-15	55.240	75.708	71.701	71.459	69.304	94.012	93.828	Continuing	Continuing

(U) <u>Mission Description:</u>

(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 U.S. 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, R-1 #45

(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. Included in this project is the Semiconductor Ultraviolet Optical Sources, the Superconducting Hybrid Power Electronics (SuperHyPE), and the Very High Speed Digital and the Mixed Signal Microsystems initiatives.

(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 speed, power, weight and volume constraints.

(U) The Microelectromechanical Systems (MEMS) and Integrated Microsystems Technology 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.

(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. Efforts in this project include Self-Synchronized Noise Systems Program, the Digital Control of Analog Circuits Program and the Anti-Tamper initiative.

(U) The Centers of Excellence (MT-07) project finances demonstration, training and deployment of advanced manufacturing technology at Marshall University and the Defense Techlink Rural Technology program. This effort will complete during FY 2003.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, R-1 #45

(U)	**Program Change Summary:** (*In Millions*)	**FY 2001**	**FY 2002**	**FY 2003**
	FY02 Amended President's Budget	219.467	177.264	159.867
	Current Budget	213.379	199.564	150.400

(U) Change Summary Explanation:

FY 2001 Decrease reflects the SBIR reprogramming and the Omnibus transfer.

FY 2002 Increase reflects congressional adds in Advanced Lithography Demonstration, Laser Plasma Point Source, X-Ray Mask Research, Novel Crystal Components for Imaging and Communications, and Defense Techlink.

FY 2003 Decrease reflects completed funding of the Uncooled Integrated Sensors project and reduced funding requirements of the Micro Power Generation program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Uncooled Integrated Sensors MT-03	12.776	6.441	0.000	0.000	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.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Uncooled Imaging Sensors & Devices. ($8.804 Million)
  - Demonstrated 100 gram imaging sensor with performance acceptable for micro-air-vehicles.
  - Optimized read-out structure to read signals with short (approximately 1 msec.) integration time.
  - Conducted three-D thermal imaging phenomenological experiments and studies.

- Electro-Optics IR Technology Center. ($3.972 Million)
  - Developed the next generation infrared and night vision sensor technology, consisting of large arrays of multi-spectral detectors, with integral signal processing, addressing systems' needs for threat warning and target acquisition.
  - Incorporated innovative detector and signal processor designs to maximize operating temperature, while maintaining the target discrimination capability at the maximum system range.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-03

(U) <u>FY 2002 Plans:</u>

- Uncooled Imaging Sensors & Devices. ($6.441 Million)
  - Incorporate high responsitivity materials into detector structure.
  - Integrate materials and microstructure into imaging device.

(U) <u>FY 2003 Plans:</u>

- Not Applicable.

(U) <u>Other Program Funding Summary Cost:</u>

- Not Applicable.

(U) <u>Schedule Profile:</u>

Plan	Milestones
Mar 02	Integrate materials and microstructure into imaging device.
Sep 02	Demonstrate five-gram sensor with sensitivity < 10 milli-Kelvin, ideal thermal imaging device.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Electronic Module Technology MT-04	38.963	35.000	21.699	31.807	29.747	29.688	29.630	Continuing	Continuing

(U) <u>Mission Description:</u>

(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. The project has three 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 Electronic Module Technology project has the following major elements: Photonic Analog/Digital (A/D) Conversion; Distributed Robotics; Design Support for Mixed Technology Integration (Composite CAD), the Molecular-level Large-area Printing (MLP), Semiconductor Ultraviolet Optical Sources (SUVOS) program and the Superconducting Hybrid Power Electronics (SuperHyPE) program. Photonic Analog/Digital (A/D) conversion will utilize breakthrough photonic developments to substantially increase the speed that 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 demonstrated approaches to ‘printing’ MEMS devices on large surfaces.

(U) The Semiconductor Ultraviolet Optical Sources (SUVOS) program will develop photonic wide band gap materials for optical emission in the ultraviolet for bio sensing, and covert communications applications. This program will develop high conductivity *p*-type (positive charge carrier) material, and highly efficiently active region material suitable for ultraviolet emission and exploit these results to enable the development of heterojunction bipolar transistors (HBT).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04

(U) An initiative in Very High Speed Digital & Mixed Signal Microsystems will address key issues to accelerate Indium Phosphide (InP) technology for the purpose of satisfying emerging DoD needs, while leveraging the pull of the potential commercial (primarily fiber optic communications) marketplace. This program, in two broad thrusts, will develop a manufacturable InP technology to demonstrate wide dynamic range mixed signal circuits operating at clock frequencies in the neighborhood of 100 GHz.

(U) Hybrid superconducting/cryogenic components will provide a new paradigm for power electronics for the "all electric" platforms of the future. Recent breakthroughs in high temperature superconducting wires will now allow superconducting power components to work effectively at temperatures as high as 77°K. Combining these superconducting components (motors, generators, energy storage devices, transmission lines, inductors, limiters) with cryogenic semiconducting power electronics will provide: a) improved controllability (via rapid response and ease of interface with digital control systems); b) significantly reduced maintenance; c) reduced complexity (reduced number of energy transformations, reduced support requirements); d) increased efficiency (less energy conversion, improved primary power sources); e) new applications (pulsed energy systems, directed energy weapons, rail guns) and last but not least, f) reduced personnel needs (fully automatic systems). These hybrid systems offer significant increases in specific power density that provide weight and volume savings that scale with the overall size of the system. This can easily translate to factors of two to three savings for a moderate size system (5000 HP) and an order of magnitude for large systems (greater than 20,000 HP). The Superconducting Hybrid Power Electronics (SuperHYPE) program will build a prototype system of moderate size that will be fully integrated from generator to load and will be operated at the optimum temperature for each subsystem.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2001 Accomplishments:</u>

- Photonic A/D. ($13.802 Million)
  - Completed initial photonic analog/digital (A/D) converter evaluation and finalized design for demonstration module.
  - Demonstrated key photonic technologies.

- Distributed Robotics. ($12.678 Million)
  - Demonstrated multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04

- Molecular-level Large-area Printing (MLP). ($12.483 Million)
  - Demonstrated and characterized 10,000 x 100 pixel density array on a spherical surface.

(U) <u>FY 2002 Plans:</u>

- Photonic A/D. ($10.557 Million)
  - Complete photonic analog/digital converter technology development.
  - Integrate photonic clock and sampler modules with electronic quantizers.
  - Complete analog/digital converters with at least 10 gigasamples/sec.
  - Demonstrate high linearity and dynamic range.

- Distributed Robotics. ($5.749 Million)
  - Complete current contracts on micro robot developments.
  - Deliver prototype hardware and final reports.
  - Demonstrate with operational military users.

- Semiconductor Ultraviolet Optical Sources (SUVOS). ($13.228 Million)
  - Demonstrate *p*-type (positive charge carrier) doping in high aluminum concentration nitride materials at concentrations sufficient for minority carrier injection devices.

- Superconducting Hybrid Power Electronics (SuperHyPE). ($5.466 Million)
  - Identify target power modules and platform for maximum benefit of hybrid approach.
  - Initiate design for integrated hybrid power module.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04

(U) **FY 2003 Plans:**

- Semiconductor Ultraviolet Optical Sources (SUVOS). ($13.600 Million)
  - Demonstrate minority carrier devices (e.g. light emitting diodes, laser diodes, heterojunction bipolar transistors).

- Very High Speed Digital & Mixed Signal Microsystems. ($3.099 Million)
  - Develop current Indium Phosphide - Integrated Circuit (InP-IC) technology to higher levels of complexity and push InP mixed signal IC technology to extreme speed (while maintaining useful breakdown voltage and noise margin).
  - Demonstrate wide dynamic range mixed signal circuits of ~ 1000 transistors.

- Superconducting Hybrid Power Electronics (SuperHYPE). ($5.000 Million)
  - Demonstrate hybrid superconducting power modules for 1 kW (satellite) and 500 kW (shipboard) with high efficiency, reliability, and reduced size and weight.

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

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Jul 02	Develop high power high temperature devices.
Sep 02	Demonstrate high temperature operation of integrated power switches.
Jul 03	Achieve wide-dynamic range mixed signal circuits of 10,000 transistors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Centers of Excellence MT-07	5.213	5.000	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 Defense Techlink Rural Technology Transfer Project.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Advanced Flexible Manufacturing. ($ 3.972 Million)
  - Continued to expand the web based electronics supply chain and increased the number of manufacturers who have access to, and qualify for, Defense acquisitions.

- Defense Techlink Rural Technology Transfer Project. ($ 1.241 Million)
  - Provided funding for the Defense Techlink Rural Technology Transfer Project.

(U) FY 2002 Plans:

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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07

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

(U) FY 2003 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
Sep 03	Complete assessment and transition of the Institute for Advanced Flexible Manufacturing from DoD to state/private support.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Advanced Lithography MT-10	54.457	36.632	25.000	25.000	25.000	0.000	0.000	0.000	N/A

(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 0.18 microns. The Advanced Lithography program emphasizes longer-term research with expected high payoff in the fabrication of semiconductor devices with 0.05 or less micron feature sizes. These efforts will develop technology for sub 0.05 micron features.

(U) The goal of the Advanced Lithography program is to reduce technical barriers to 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 0.05 μm resolution over field areas in excess of 1000 mm^2. Applications with larger geometries will be explored for innovative devices and structures beyond microelectronics, including nanolithography.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Sub 0.1 Micron Lithographies. ($23.031 Million)
  - Demonstrated key components of maskless wafer writer and key components for lithography of 0.07 micron features.

- Support Technologies. ($17.822 Million)
  - Accelerated technology developments in the lithography exposure sources and supporting (cross-cutting) technologies needed for microelectronics fabrication.
  - 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.

- Laser Plasma X-Ray Source. ($4.965 Million)
  - Continued laser plasma x-ray source technology.

- Point Source Lithography. ($3.674 Million)
  - Continued point source lithography development.

- Advanced Lithography Mask Development. ($4.965 Million)
  - Continued lithography mask development.

(U) FY 2002 Plans:

- Sub 0.1 Micron Lithographies. ($14.532 Million)
  - Develop key tool components, materials and processing for both maskless and projection approaches for lithography at 0.05 microns and below.
  - Fabricate prototype devices for military applications with features at 0.1 micron.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10

- Support Technologies. ($10.000 Million)
  - Develop mask technology (writing, inspection and repair), resists and metrology for lithography for sub 0.1 micron.
  - Develop thinner resists appropriate for emerging exposure sources.

- Laser Plasma X-Ray Source. ($4.300 Million)
  - Continue laser plasma x-ray source technology.

- Advanced Lithography Development. ($4.300 Million)
  - Continue point source lithography development.

- Advanced Lithography X-Ray Mask Development. ($3.500 Million)
  - Continue lithography X-Ray mask development.

(U) FY 2003 Plans:

- Sub 0.1 Micron Lithographies. ($15.000 Million)
  - Develop and demonstrate key subsystems for both maskless and projection approaches for lithography technologies that will extend to 0.05 microns and below.
  - Fabricate prototype tools for fabrication of devices with 0.07 micron features.
  - Explore nanolithography with features down to the range of 10 nm.

- Support Technologies. ($10.000 Million)
  - Develop mask technology (writing, inspection and repair), resists and metrology for lithography for 0.05 micron and below.
  - Exploit advances from longer term developments in direct write-on-wafer projects.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10

(U) Schedule Profile:

Plan	Milestones
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.
Aug 03	Demonstrate prototype tool for fabrication of devices with 0.07 micron features.
Aug 04	Demonstrate key components for fabrication of devices with 0.05 micron features.
Aug 05	Demonstrate prototype tool for fabrication of devices with 0.05 micron features.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2002			
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12				
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
MEMS and Integrated Micro-systems Technology MT-12	46.730	40.783	28.000	19.804	19.725	19.792	19.753	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-

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

power generators based on mechanical actuation and thermal-electric power generation. Operating with traditional fuels, these micropower 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) A new initiative in chip-scale micro-coolers aims to demonstrate MEMS Technology for fabrication of chip-scale micro-cooling elements.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2001 Accomplishments:</u>

- MEMS Micro Power Generation. ($18.907 Million)
  - Demonstrated chip-level integration of components for fuel processing, thermal management, energy conversion and exhaust management for micropower generation. Enabled stand alone, remotely distributed microsensors with built-in power supply and RF communication in addition to various sensing functions.
  - Developed MEMS free-piston knock engine.
  - Developed an integrated fuel cell and fuel processor for microscale power generation from liquid fuels.
  - Developed integrated chemical fuel microprocessor for power generation in MEMS applications.
  - Developed 3-D monolithically fabricated thermoelectric micro generator.

- CAMD. ($2.731 Million)
  - Continued micro device manufacturing process at the Center for Advanced Microstructures and Devices (CAMD).

- Deep Silicon Etching. ($7.944 Million)
  - Continued MEMs Deep Etching program in conjunction with the Army Research Laboratory.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

- Bio-Fluidic Chips (BioFlips). ($17.148 Million)
  - Developed closed-loop bio-fluidic chips to regulate cellular transduction pathways and precise dosage of chemicals/drugs/ reagents/enzymes.
  - Fabricated and tested individual microfluidic chip components and integrated sensors for flow control.
  - Manipulated (pump/valve/sense) bio-fluids in integrable microfluid components.

(U) <u>FY 2002 Plans:</u>

- MEMS Micro Power Generation. ($18.804 Million)
  - Demonstrate capabilities in fuel processing, energy conversion to electricity, thermal and exhaust management.
  - Demonstrate MEMS micro heat engines utilizing micropower sources.

- Bio-Fluidic Chips (BioFlips). ($16.779 Million)
  - Demonstrate optimization of sub-systems and components for integration into prototype systems. Sub-systems include: 1) on-chip sample preparation and processing (on-chip flow/concentration regulators, biosignal amplification, on-chip pressure sources, on chip separation/mixing, reagents storage/reconstitution); 2) sample collection (body fluid extractors, concentrators); and 3) antidote synthesis (genetic and antibodies) subsystems.
  - Identify partners in the DoD and other federal agencies for testing prototype systems.
  - Perform preliminary testing of prototype systems for re-evaluation of sub-system functionality.

- Deep Silicon Etching. ($5.200 Million)
  - Complete MEMS Deep Etching program in conjunction with Army Research Laboratory.

(U) <u>FY 2003 Plans:</u>

- MEMS Micro Power Generation. ($9.512 Million)
  - Demonstrate integration of various power-generation components with microsensors and microactuators.
  - Demonstrate stand alone, remotely distributed microsensors and actuators with built-in power supply and wireless communication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	**R-1 ITEM NOMENCLATURE** Advanced Electronics Technology PE 0603739E, Project MT-12

- Bio-Fluidic Chips (BioFlips). ($13.317 Million)
  - Modify sub-systems based on preliminary testing of prototype systems.
  - Finalize testing of prototype systems to optimize integrated performance.
  - Demonstrate prototype BioFlip systems in field insertions.

- Chip Scale MEMS Micro-Cooler. ($5.171 Million)
  - Demonstrate MEMS Technology for fabrication of chip-scale cooling elements.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Jul 02	Demonstrate BioFlips optimization of sub-systems and components.
Feb 02	Demonstrate micro heat engines.
Aug 03	Demonstrate electrical power generation.
Aug 03	Test and optimize BioFlips prototype.
Sep 03	Demonstrate stand-alone microsensors with integrated micropower source and wireless communication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Mixed Technology Integration MT-15	55.240	75.708	71.701	71.459	69.304	94.012	93.828	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. These 'wristwatch 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 of mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) The field of 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 'matchbook-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 microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

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) The 3-Dimensional Imaging Devices program is developing new high speed imaging devices and array technology to rapidly acquire high resolution (less than 6 inches in range) three dimensional images of tactical targets at ranges of 7 to 10 kilometers, thereby increasing identification range of tactical targets, especially from fast moving platforms.

(U) The Steered Agile Laser Beams (STAB) program is developing small, lightweight laser beam scanning technologies for the replacement of large, heavy gimbaled mirror systems. New solid state/micro-component technologies such as optical MEMs, patterned liquid crystals and diffractive micro-optics will be used to build small, ultra-light, rapidly steered laser beam sub-systems.

(U) The Radio Frequency (RF) Lightwave Integrated Circuits (RFLICS) program is demonstrating enhanced performance capabilities of RF systems enabled by integration of lightwave and RF technologies to route, control, and process analog RF signals in the 0.5 – 50 Ghz range.

(U) The Nano Mechanical Array Signal Processors (NMASP) will create arrays of precision, nano mechanical structures for radio frequency (RF) signal processing that will greatly reduce the size and power consumption of various communication systems.

(U) The goal of the Chip Scale Wavelength Division Multiplexing (WDM) program is to develop new materials, components and sub-systems for use in wavelength division multiplexing based optical communications, delivering high capacity, mission adaptable networks for use in data intensive military weapons systems.

(U) The objective of the Multi-function Imaging Micro-systems program is to develop and demonstrate a new class of uncooled low power, light weight sensors, with an integral intelligent imaging capability, including target discrimination, multi-spectral band imaging, sensor radiation shielding and on-chip signal processing.

(U) The Self-Synchronized Noise Systems program will exploit advances in nano-scale CMOS, high speed Si-Ge and MEMS RF filter technologies to demonstrate the capability to generate, detect, and process chaotic (noise-like) electromagnetic signals that have self-synchronization

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

properties. The effort will develop high performance signal generators and detectors (correlators, convolution processors, filter, etc.) that implement and invert chaotic functions that have self-synchronization properties.

(U) Digital Control of Analog Circuits will demonstrate analog/RF electronic components with the ability to self-assess and adapt in real time (sub microseconds), by self-tuning its impedance-matched networks, extending the operational performance of analog components to the intrinsic semiconductor device limits. This technology will result in a new generation of analog, microwave and millimeter wave components with >150X improvements in power-bandwidth, linearity-efficiency products.

(U) The goal of the Anti-Tamper (AT) initiative is to protect selected critical technologies in U.S. weapons systems that may be developed with or sold to foreign governments or that could possibly fall into enemy hands. Specifically, AT is intended to prevent technology transfer, alteration of system capability, and development of countermeasures due to weapon system co-development, sales, or potential loss on the battlefield. An AT technology base will develop complimentary AT techniques with broad applicability across the range of DoD critical technologies. Areas of AT technology interest include software, digital electronics, materials, and systems operating across the electromagnetic spectrum.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2001 Accomplishments:</u>

- 3-D Imaging Devices. ($20.980 Million)
  - Completed design of high-speed electronics for sub-nanosecond detection.
  - Initiated experiments in exploiting and adapting emerging technology in nanofabrication to create nano resonators by chemical and physical transfer of materials on nano-scale patterns.
  - Integrated high-speed electronics with 5x5-detector array and integrated into brass board imaging system.
  - Demonstrated laboratory imaging with 5x5 array.
  - Selected detector design for 128x128 3-D imaging array.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

- Steered Agile Laser Beams (STAB). ($17.840 Million)
  - Developed electronically steered laser beam technology for use in covert, anti-jam, high bandwidth battlefield communications - hand held ground-to-ground recon units that 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.
  - Fabricated beam steering emitters and detectors.

- RF Lightwave Integrated Circuits (RFLICS). ($16.420 Million)
  - Focused program on key applications for integrated RF-Photonic modules and produced initial prototypes and demonstrated methods for evaluation of their performance.
  - Initiated 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-selected among technology options and developed prototype module for demonstration.

(U) **FY 2002 Plans:**

- 3-D Imaging Devices. ($12.711 Million)
  - Demonstrate range imaging at the eye-safe wavelength of 1.54 micrometers, with a minimum array size of 64x64. The goal is target identification range of 10 km with single laser pulse imaging.
  - Demonstrate 480 x 640 array with 20 mk sensitivity.
  - Investigate polarization structures, with uncooled arrays.
  - Integrate photon and thermal detectors on the same chip, with dual mode read-out.

- Steered Agile Laser Beams (STAB). ($12.339 Million)
  - Analyze system concepts that will be used to develop design goals for assembled components.
  - Fabricate individual laser beam steering components (lasers, diffractive optics, micro electro-mechanical (MEMS) sub-assemblies, detectors, filters and integrated circuits).
  - Resolve component interface issues in preparation for breadboard development.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15	

- RF Lightwave Integrated Circuits (RFLICS). ($10.661 Million)
  - Determine the quantitative performance requirements of computationally intensive weapons systems tasks such as RF channnelization, local oscillator distribution, antenna beam forming, jammer nulling, and signal synthesis and frequency conversion.
  - Use results of earlier RF photonics single chip development effort to establish goals for RF photonic component fabrication.
  - Integrate recently developed emitters, waveguides, detectors and integrated circuits to produce RF photonic component prototypes.

- Nano Mechanical Array Signal Processor (NMASP). ($10.686 Million)
  - Demonstrate fabrication techniques to control surface morphology, geometry, and material properties at the sub-micron scale.
  - Demonstrate temperature stability and electrical tenability of individual nano resonators suitable for UHF communication.
  - Initiate development of nano mechanical array signal processors that will enable ultra miniaturized (wristwatch or hearing aid in size) and ultra low power UHF communicators/GPS receivers.

- Digital Control of Analog Circuits RF Front Ends. ($6.916 Million)
  - Demonstrate real-time active self-assessment and monitoring of RF/analog functions using nano-CMOS digital and mixed-signal technologies to achieve stability, signal agility, and multifunctionality.
  - Design processes to fabricate arrays of molecular flow control devices including interconnect microfluidics and electronics.

- Chip Scale Wavelength Division Multiplexing (WDM). ($8.395 Million)
  - Conduct modeling, simulation and analysis of artificial dielectrics and new materials for ultra-compact Wavelength Division Multiplexing (WDM) components.
  - Conduct experimental efforts in the growth and fabrication of these new materials and determine suitable processing procedures.
  - Plan construction of WDM components.

- Anti-Tamper (AT). ($8.000 Million)
  - Facilitate information exchanges throughout the Services, DoD Agencies and Labs and industry to preclude development of duplicative technologies.
  - Develop an interactive AT databank and library.
  - Develop a technology roadmap required to prioritize the overall technological research and development effort.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

– Develop AT technology throughout the Radio/Frequency/Gallium Arsenide and Digital Gallium Arsenide domains.

- Novel Crystal Components for Imaging and Communications. ($6.000 Million)
  – Initiate component development.

(U) **FY 2003 Plans:**

- Steered Agile Laser Beams (STAB). ($10.463 Million)
  – Evaluate competing laser beam steering component technologies; down-select to the most promising approaches.
  – Complete prototype design studies.
  – Assemble and test components suitable for use in prototype demonstration and evaluation.
  – Assess performance characteristics of the prototypes and make recommendations for future development.

- RF Lightwave Integrated Circuits (RFLICS). ($5.707 Million)
  – Complete the design and fabrication of RF photonic prototypes.
  – Construct testbeds capable of producing realistic systems demands for the demonstration and evaluation of RF lightwave integrated circuit components and assemblies.
  – Measure and analyze the operational impact of the photonic domain for advanced RF signal transmission, conditioning and processing.

- Nano Mechanical Array Signal Processor (NMASP). ($15.000 Million)
  – Demonstrate several alternatives to achieve uniform arrays of up to 1024 nano resonators with geometrical control and material uniformity at $\pm$20%, and to $\pm$1% with trimming and tuning.
  – Demonstrate interconnection and isolation (multiplexed, serial, or random access) of individual resonators.

- Chip Scale Wavelength Division Multiplexing (WDM). ($13.000 Million)
  – Design, fabricate and test novel WDM components using the new materials and processing technology.
  – Determine fiberoptic and planar waveguide interconnection requirements.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

- Evaluate the suitability of the new components for use in prototype modules.
- Down-select to the most promising approaches and begin prototype module assembly.
- Construct testbeds capable of fully measuring and characterizing the new technologies implemented in the chip-scale WDM components.
- Evaluate the performance characteristics of the prototype modules and determine the highest payoff dual use development paths.

- Digital Control of Analog Circuits RF Front Ends. ($7.000 Million)
  - Develop techniques and algorithms to monitor active device status.
  - Demonstrate MEMs tunable device optimization (<1 microsecond, 10:1 tuning ratio).
  - Fabricate tunable MEMs control Integrated Circuits (ICS).
  - Fabricate self-assessment control Integrated Circuits (ICS).

- Multi-Function Imaging Microsystems. ($12.000 Million)
  - Demonstrate 320 x 240 photon detector array integrated with a microbolometer array.
  - Demonstrate 320 x 240 imaging with solid state radiation shield temperature reduction of 20 K.
  - Demonstrate mid wave room temperature array 320 x 240 with sensitivity suitable for imaging.

- Self-Synchronized Noise Systems. ($8.531 Million)
  - Demonstrate capability to detect and process chaotic electromagnetic signals.
  - Develop high performance signal generators and detectors.

(U) <u>Other Program Funding Summary Cost:</u>

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Schedule Profile:

Plan	Milestones
3-D Imaging:	
Jun 02	Demonstrate range imaging at eye safe wavelengths.
STAB:	
Jul 02	Fabricate laser beam steering components.
May 03	Complete prototype design studies.
RFLICS:	
Aug 02	Integrate emitters, waveguides and detectors into RF photonic component prototypes.
Sep 03	Complete design and fabrication of RF photonic prototypes.
WDM:	
Aug 02	Develop artificial dielectrics suitable for compact WDM modules.
Aug 03	Design, fabricate, and test WDM modules.
NMASP:	
Jul 02	Demonstrate electrically controlled tunability suitable for UHF communication.
Aug 03	Demonstrate arrays up to 1024 nano resonators with geometrical control and material uniformity at $\pm$20%, and to $\pm$1% with trimming and tuning.
Digital Control:	
Jul 02	Demonstrate RF/analog functions using mixed-signal technologies.
Jun 03	Demonstrate MEMS tunable devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

Self Synchronized Noise Systems:

Aug 03	Demonstrate capability to detect and process electromagnetic signals

Multifunction Imaging Microsystems:

Feb 03	Demonstrate 320 x 240 imaging with solid state radiation shield showing temperature reduction of 20K.
Mar 03	Demonstrate polarization sensitivity in an uncooled LWIR array.
Jun 03	Demonstrate mid wave room temperature array 320 x 240 with sensitivity suitable for imaging.