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).

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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.).

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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.

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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.

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- 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.

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- 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.

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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.

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(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.

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- 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.

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- 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.

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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.

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(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.

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- 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.

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- 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.

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- 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.

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- 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.

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- 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.

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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.

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- 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.

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(U) **Schedule Profile:**

- Not Applicable.