RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2005	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20				
COST (In Millions)	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Total Program Element (PE) Cost	0.000	261.406	241.736	249.453	250.501	250.425	250.425	250.425
Electronics Technology ELT-01	0.000	261.406	241.736	249.453	250.501	250.425	250.425	250.425

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research budget activity because its objective is to develop electronics that make possible a wide range of military applications.

(U) Advances in microelectronic device technologies, including digital, analog, photonic and microelectromechanical (MEMS) devices, continue to have significant impact in support of defense technologies for improved weapons effectiveness, improved intelligence capabilities and enhanced information superiority. The Electronics Technology program element supports the continued advancement of these technologies through the development of performance driven advanced capabilities, exceeding that available through commercial sources, in electronic, optoelectronic and MEMS devices, semiconductor device design and fabrication techniques, and new materials and material structures for device applications. A particular focus for this work is the exploitation of chip-scale heterogeneous integration technologies that permit the optimization of device and integrated module performance.

(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. Another thrust of the program element 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. Projects 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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

incorporating these components for such applications as low cost seamless pervasive computing, ultra-fast computing, and sensing and actuation devices. This program element was created in accordance with congressional intent in the FY 2005 DoD appropriations bill. Prior year funding was budgeted in PE 0602712E, Projects MPT-02 and MPT-08 and is noted as a memo entry in the programs below.

(U) **Program Accomplishments/Planned Programs:**

	FY 2004	FY 2005	FY 2006	FY 2007
Adaptive Focal Plan Arrays (AFPA)	(10.175)	7.503	5.274	3.039

(U) The goal of this program is to demonstrate high-performance focal plane arrays that are widely tunable across the entire infrared (IR) spectrum (including the short, middle and long-wave infrared bands), thus enabling "hyperspectral imaging on a chip." The Adaptive Focal Plane Array (AFPA) program will also allow for broadband Forward Looking Infrared (FLIR) imaging with high spatial resolution. These AFPAs will be electrically tunable on a pixel-by-pixel basis, thus enabling the real-time reconfiguration of the array to maximize either spectral coverage or spatial resolution. The AFPAs will not simply be multi-functional, but rather will be adaptable by means of electronic control at each pixel. Thus, the AFPAs will serve as an intelligent front-end to an optoelectronic microsystem. The AFPA program outcome will be a large format focal plane array that provides the best of both FLIR and Hyper-Spectral Imaging (HSI).

(U) Program Plans:
- Develop component technology (tunable IR photodetectors).
- Integrate detector array.
- Demonstrate pixel-by-pixel electrical tunability in IR.
- Demonstrate AFPA prototype field using a large format array.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Vertically Interconnected Sensor Arrays (VISA)	(12.681)	8.526	3.358	2.000

(U) The Vertically Interconnected Sensor Arrays (VISA) program will develop and demonstrate vertically interconnected, focal plane array (FPA) read-out technology capable of more than 20-bits of dynamic range, enabling significant advances in the functionality of infrared systems. The extremely high dynamic range will be accomplished by novel multilayer read-out circuits. These circuits will enable imaging at more than 20-bits of dynamic range, whereas the current state of the art is over an order of magnitude lower. Adaptive read-out circuits will be vertically connected to individual detectors in either monochromatic or stacked multicolor 2D staring arrays. The ability to bring signal directly from the detectors to the read-outs (i.e., vertical interconnection) without first going through row-column multiplexers will allow for high frame rates concurrently with high resolution images. A companion application-oriented program is funded in 6.3 (PE0603739E).

(U) Program Plans:

- Develop a wafer stacking process incorporating high-density vias and design novel circuits that enable high frame rates, counter-measure hardening and adaptive signal processing functions on a concept test chip.
- Demonstrate a high dynamic range Analog/Digital VISA technology based sensor designed with advanced high performance circuit architecture implemented in stacked semiconductor process with high-density interconnections.
- Determine the best bands for improving the detection of objects in varying degrees of fog.

	FY 2004	FY 2005	FY 2006	FY 2007
Terahertz Imaging Focal-Plane Technology (TIFT)	(7.542)	9.625	10.000	10.000

(U) The TIFT program, formerly Imaging Coherent Optical Radar, will demonstrate large, multi-element (> 40K pixels) detector receiver focal plane arrays that respond to radiation in the THz band (> 0.557 THz). The sensor system will be able to operate effectively at standoff range (>25m) with a high spatial resolution (< 2 cm) limited only by beam diffraction. The imaging receiver will produce a two-dimensional (2D) image in which each pixel records the relative intensity of the THz radiation received on the focal plane within the appropriate section of the field of view of the scene being sensed. The program will achieve intensity sensitivities as close as possible to the thermal background limit at room

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

temperature. The minimal acceptable acquisition time is video-rate (30 Hz). The receiver may be either passive or active (including THz time domain methods). The size, weight, and electrical power requirements will be consistent with portability.

(U) Program Plans:

- Demonstrate revolutionary component and integration technologies necessary for the development of a diffraction-limited, video-rate THz (at least 0.557 x 10^{12}Hz) frequency imaging imager.
- Demonstrate a compact THz source achieving at least 10 mW of average power and 1% wall plug efficiency, as required for active illumination and/or for local oscillators in heterodyne or homodyne detection schemes.
- Demonstrate a THz receiver capable of achieving a noise equivalent power of less than 1 pW/Hz $^{1/2}$ as measured with an integrated acquisition time of no more than 30 ms and a pre-detection bandwidth of no more than 50 GHz, as required in order to achieve a system-level noise equivalent delta temperature of 1K or better.

	FY 2004	FY 2005	FY 2006	FY 2007
3-D Microelectromagentic RF systems (3-D MERFS)	(4.130)	4.924	4.736	1.970

(U) The 3-D Microelectromagnetic RF systems (3-D MERFS) program will develop complete millimeter wave active arrays on a single or a very small number of wafers. The program will exploit new technologies being developed commercially that allow GaAs active components to be placed on Si wafers, and advances in InP and SiGe that may allow an entire MMW Electronically Scanned Array (ESA) to become very highly integrated on a sandwich of wafers. At lower frequencies, the large spacing between radiating elements precludes the efficient use of the wafer real estate for fabricating the entire ESA, but at Ka and W- bands, the element spacing is small enough to allow an ESA to be made with active transmit/receive chips and control circuits on one layer, radiators on another, and a feed system on a third. This could potentially make them very cheap, compact, lightweight and reliable. This would enable the development of new MMW ESAs of a six inch diameter or less for seekers, communication arrays for point-to-point communications, sensors for smart munitions, robotics and small remotely piloted vehicles. This program will build upon technology developed under the Vertically Interconnected Sensor Array program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:
- Survey the emerging commercial MMW technology base and identify the best candidate processes for the MMW ESA application.
- Develop the optimal ESA architectures for wafer fabrication.
- Determine requirements for MMW ESAs that match the expected performance.
- Design, build, and test candidate ESA designs.
- Design, build, and test full ESA seeker or other system using the wafer fabrication technology.

	FY 2004	FY 2005	FY 2006	FY 2007
Analog Optical Signal Processing (AOSP)	(12.538)	8.500	0.000	0.000

(U) Analog Optical Signal Processing (AOSP) will significantly enhance the performance of, and enable entirely new capabilities and architectures for tactical and strategic RF systems. The program will expand the dynamic range-bandwidth and time-bandwidth limits by a factor of 1,000 through the introduction of analog optical signal processing components into the system front ends.

(U) Program Plans:
- Perform analysis of analog signal characteristics of military RF systems.
- Create, model and simulate new photonic-based optical signal processing techniques of ultra-high bandwidth analog signals.
- Evaluate anticipated system performance improvements due to novel signal processing algorithms and determine the resulting photonic component performance requirements.
- Test and evaluate signal processing techniques of analog signals.
- Evaluate photonic component performance requirements.
- Design, fabricate and test individual photonic components capable of meeting RF signal processing requirements.
- Determine the most promising approaches for development of integrated, chip-scale components using new materials and processing technologies.
- Determine interface requirements.
- Evaluate the suitability of the new components for use in prototype modules.
- Down-select to the most promising approaches and begin prototype module assembly.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

– Construct testbeds capable of fully characterizing the photonic-based RF signal processing components.

	FY 2004	FY 2005	FY 2006	FY 2007
Advanced Precision Optical Oscillator (APROPOS)	(7.914)	4.904	4.599	2.150

(U) The APROPOS program will leverage advances in materials and lasers to develop new precision microwave-stable local oscillators with extremely low phase noise (up to 50 dB better than the current state of the art) at small offsets from microwave carrier frequencies. This capability will enhance performance of radar, electronic warfare and communications systems in weak signal detection at increased stand off ranges, slow moving target detection, clutter suppression, and electronic warfare "fingerprinting (specific emitter identification).

(U) Program Plans:
- Improve phase noise power spectral density by 25 dB and prove the utility of multi-line laser cavities and opto-electronic oscillators.
- Identify and characterize environmental susceptibilities and define path to 50 dB improvement over state of the art.
- Demonstrate 50 dB improvements in lab setting.
- Develop miniaturization approach and packing concept to mitigate environmental susceptibilities.
- Miniaturize devices in ruggedized packages.
- Demonstrate performance in tactical environments insert in system testbeds.

	FY 2004	FY 2005	FY 2006	FY 2007
Advanced Digital Receiver	(0.000)	2.800	2.200	0.000

(U) The Advanced Digital Receiver program will leverage and improve Analog to Digital Converter (ADC) technology to develop Digital Receivers with greatly enhanced performance. Goals include reducing size, weight and power by an order of magnitude, enhancing programmability, flexibility and performance, reducing life cycle cost, and developing ADCs with 16 effective bits, 100 MHz instantaneous bandwidth and >100 dB spurious free dynamic range (SFDR).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:
- Demonstrate 1st Pass Sigma-delta Modulator in test fixture.
- Demonstrate 2nd Pass Sigma-delta Modulator in test fixture with ADC-DAC Iteration 1.
- Demonstrate Real-time Digital Receiver Operation by Benchtop Integration of Best Sigma-delta Test Fixture and WAR Decoder Test Fixture.
- Demonstrate 3rd Pass Sigma-delta Modulator in test fixture with ADC-DAC Iteration 2.
- Demonstrate Real-time Digital Receiver Module Prototype (provide 5 modules).

	FY 2004	FY 2005	FY 2006	FY 2007
Chip Scale Atomic Clock	(17.957)	12.840	7.828	5.500

(U) The Chip Scale Atomic Clock will demonstrate a low-power chip scale atomic-resonance-based time-reference unit with stability better than one part per billion in one second. Application examples of this program will include the time reference unit used for GPS signal locking.

(U) Program Plans:
- Demonstrate feasibility and theoretical limits of miniaturization of cesium clock.
- Demonstrate subcomponent fabrication, including atomic chamber, excitation and detection function.
- Demonstrate design and fabrication innovation for atomic-confinement cell and for GHz resonators suitable for phase locking or direct coupling with atomic confinement cell.

	FY 2004	FY 2005	FY 2006	FY 2007
Technology Efficient, Agile Mixed Signal Microsystem (TEAM)	(15.137)	16.332	12.570	7.000

(U) Technology for Efficient, Agile Mixed Signal Microsystems (TEAM) will enable fabrication of high performance mixed signal systems-on-chip that will be the core of the embedded electronics in new platforms that are constrained by size and on-board power.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:

- Develop and demonstrate nanoscale silicon-based structures and associated fabrication processes to achieve high-speed analog/RF functions.
- Optimize device and process parameters for high speed mixed signal circuits.
- Produce test devices for analog/RF parameter extraction.
- Demonstrate Complementary Metal Oxide Semiconductor (CMOS) compatible fabrication processes that can yield integration levels greater than 10,000 nanoscale devices.
- Initiate highly parallel densely interconnected architectures with micron-sized vias penetrating stacks of detectors, analog, mixed signal and digital circuits.
- Demonstrate operation of high performance mixed signal circuits based on nanoscale devices.
- Demonstrate low noise interface and high isolation (up to 100 db) between high performance analog circuits and associated digital signal processing.
- Fabricate mixed signal systems on chip with nanoscale transistors.

	FY 2004	FY 2005	FY 2006	FY 2007
Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST)	(21.996)	18.591	10.014	0.000

(U) The TFAST program (Ultra High Speed Circuit Technology) will develop super-scaled Indium Phosphide (InP) Heterojunction Bipolar Transistor (HBT) technology compatible with a ten-fold increase in transistor integration for complex mixed signal circuits. Phase I will establish the core transistor and circuit technology to enable the demonstration of critical small scale circuit building blocks suitable for complex mixed signal circuits operating at speeds three times that currently achievable and ten times lower power. Phase II will extend the technology to the demonstration of complex (more than 20,000 transistors) mixed signal circuits with an emphasis on direct digital synthesizers for frequency agile transmitters.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:
- Develop material and process technology for super-scaled InP double heterostructure bipolar transistors (DHBTs). Technical approaches will leverage the process technology used in the silicon, and silicon germanium, industry to produce a planar, highly scalable InP HBT.
- Extend the core DHBT and interconnect technology with the implementation of complex mixed signal circuits.
- Develop super-scaled InP HBT processing technology for 0.25 micron and below.
- Develop high current, planar, InP HBTs compatible with high levels of integration.
- Develop greater than 100 GHz mixed signal circuit building blocks.
- Demonstrate record performance InP HBTs in a planar process for complex mixed signal circuits.
- Demonstrate critical mixed signal building block circuit operating at more than 100 GHz.
- Develop circuit designs for direct digital frequency synthesizers (DDS) operating with clock speed up to 30 GHz.
- Define circuit designs and layouts for mm-wave DDS and related complex mixed signal circuits.
- Develop full circuit capability using super-scaled InP HBTs in complex (more than 20,000 transistor) circuits.
- Establish device models and critical design rules.

	FY 2004	FY 2005	FY 2006	FY 2007
Clockless Logic	(5.800)	4.900	4.700	0.000

(U) The Clockless Logic program goal is to develop techniques to reduce the amount of design resources required in chip design and significantly reduce the power and noise to provide improved system operation. Clockless methods will provide more efficient designs especially for military systems with demanding space, weight, power, and noise constraints.

(U) Program Plans:
- Develop method for design of complex chips using clockless logic.
- Enhance tools and methods for design of clockless logic circuits and systems.
- Identify and design complex chips with significant potential for improved system performance and reduced design times.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

- Apply clockless design methods to programmable logic devices to provide significant potential for improved system performance and reduced design times.
- Demonstrate performance enhancements of complex chip enabled by clockless logic in radar or similar testbed.

	FY 2004	FY 2005	FY 2006	FY 2007
Optoelectronics for Coherent Optical Transmission & Signal Processing	(0.000)	0.000	5.604	7.500

(U) The goal of this program is to develop optoelectronic component technologies that enable increased physical layer security in optical transmission systems through the synergistic use of coherent optical technologies and high-speed electronics. Secure, high-capacity free-space communications is essential for the transformational communications architecture to be realized. Both digital and analog transmission will be considered.

(U) Program Plans:
- Develop compact stable lasers, local oscillators and frequency combs (<10 Hz linewidths with < 1 kHz long-term accuracy), high-speed quadrature optical modulators (>6 bit/s/Hz spectral efficiency with 100 GHz signaling rates), and digital homodyne receivers.
- Transition into airborne, space and maritime platforms where secure, high-capacity military optical networks for targeting and imaging are coveted.

	FY 2004	FY 2005	FY 2006	FY 2007
Design Tools for 3-Dimensional Electronic Circuit Integration	(10.921)	11.843	10.649	11.272

(U) This program will develop a new generation of Computer Aided Design (CAD) tools to enable the design of integrated three-dimensional electronic circuits. The program will focus on methodologies to analyze and assess coupled electrical and thermal performance of electronic circuits and tools for the coupled optimization of parameters such as integration density, cross talk, interconnect latency and thermal management. The goals of this initiative are to develop a robust 3-D circuit technology through the development of advanced process capabilities and the design tools needed to fully exploit a true 3-D technology for producing high performance circuits. The deliverables from this program will have a

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

significant impact on the design of mixed signal (digital/analog/RF) systems and Systems-on-a-Chip for high performance sensing, communication and processing systems for future military requirements.

(U) Program Plans:
- Apply 3D design tools to test structure.
- Fabricate and test structures.
- Verify models against data.

	FY 2004	FY 2005	FY 2006	FY 2007
Chip-to-Chip Optical Interconnects	(3.197)	9.000	6.425	3.000

(U) Continuing advances in integrated circuits technology are expected to push the clock rates of Complimentary Metal Oxide Semiconductor (CMOS) chips into 10GHz range over next five-to-seven years. At the same time, copper-based technologies for implementing large number of high speed channels for routing these signals on a printed circuit board and back planes are expected to run into fundamental difficulties. This performance gap in the on-chip and between-chip interconnection technology will create data throughput bottlenecks affecting military-critical sensor signal processing systems. To address this pressing issue, this program will develop optical technology for implementing chip-to chip interconnects at the board and back plane level.

(U) Program Plans:
- Develop high-linear density, low loss optical data transport channels that can be routed to ~1 meter distance in a geometric form factor compatible with a printed circuit board.
- Demonstrate high speed (faster then 10 GBps), low power (less then 50 mW) optical transmitter/receivers.
- Integrate optical transmitters/receivers and optical data paths with electronic packaging and manufacturing approaches.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Multiple Optical Non-redundant Aperture Generalized Sensors (MONTAGE)	(0.000)	5.454	4.766	2.172

(U) The MONTAGE program will implement a revolutionary change in the design principles for imaging sensor systems, enabling radical transformation of the form, fit, and function of these systems for a wide variety of high-value DoD applications. Significant improvements in the performance, affordability, and deployability of imaging sensor systems will be obtained through rational co-design and joint optimization of the imaging optics, the photo sensor array and the post-processing algorithms. By reaching well beyond conventional designs, MONTAGE sensors will realize optimal distribution of information handling functions between analog optics and digital post-detection processing.

(U) Specific demonstrations include reduction of the depth/thickness of an imaging sensor by an order of magnitude without compromising its light gathering ability or resolution. This dramatic reduction in thickness will then allow the imaging sensors to be deployed conformally around a curved surface of a platform (e.g., UAV, tank, or helmet). Furthermore, the flexibility generated by the incorporation of post-processing in the image formation will allow variable resolution image formation, which in turn reduces the data load for subsequent image exploitation and communication systems. Advanced post-processing algorithms will support video operation at frame rates in excess of 10 frames per second using standard computing platforms.

(U) Program Plans:

- Develop novel optical designs allowing depth reduction by 10X.
- Concurrent with optics design, develop sensor array design and post-processing algorithms to realize signal-to-noise ratio and resolution of comparable optical aperture.
- Demonstrate ability to allocate highest spatial resolution to specified regions of interest in the image while maintaining medium resolution elsewhere.
- Develop architectures for surpassing detector size-limited resolution and potentially exceed optically limited resolution.
- Demonstrate operation of a thin imaging system deployed on a curved surface.
- Demonstrate real time performance of thin imaging systems in representative DoD applications with performance evaluated using application-specific metrics for image quality, sensor cost, power consumption, mechanical properties.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
High Frequency Wide Band Gap Semiconductor Electronics Technology	(24.778)	12.000	20.000	20.000

(U) The High Frequency Wide Band Gap Semiconductor Electronics Technology program is developing wide band gap semiconductor technology and will demonstrate high performance, cost effective high power electronic devices that exploit the unique properties of wide band gap semiconductors. This program will develop low defect epitaxial films, high yield fabrication processes, and device structures for integrated electronic devices for emitting and detecting high power radio frequency/microwave radiation, and high power delivery and control.

(U) Program Plans:

- Develop bulk and surface process technologies for reducing or mitigating crystallographic defects in wide band gap materials.
- Develop semi-insulating substrates for high frequency devices.
- Design high power enclosures for microwave electronic assemblies.
- Demonstrate large periphery high power devices suitable for microwave and mm-wave operation.
- Demonstrate process reproducibility and minimization of yield limiting factors.
- Establish device characterization for very high power solid-state amplifiers.
- Demonstrate 100 mm SiC and wide band gap alternate substrates with less than 80 micropipe/cm^2 and resistivity 10^6 ohms-cm.
- Demonstrate epitaxial processes that yield + 3 percent uniformity over 75 mm wide bandgap substrates.
- Initiate thermal management study to determine best packaging approach for high power, high frequency microwave and millimeter wave transistors.
- Demonstrate 100 mm SiC and wide band gap alternate substrates with less than 40 micropipe/cm^2 and resistivity 10^7 ohms-cm.
- Demonstrate epitaxial processes that yield + 1 percent uniformity over 100 mm wide bandgap substrates.
- Identify fabrication processes for robust microwave and mm-wave devices. Identify thermal management concepts to sustain more than 1 KW/cm2 power density in high power devices.
- Optimize wide band gap semiconductor materials to achieve 100 mm substrates with less than 10 micropipe/cm^2 and resistivity greater than 10^7 ohms-cm at room temperature.
- Demonstrate fabrication processes for robust microwave and mm-wave devices with RF yields greater than 70 percent.
- Demonstrate thermal management concepts to sustain more than 1KW/cm^2 power density in high power devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
High Power Wide Band Gap Semiconductor Electronics Technology	(11.241)	13.877	10.000	15.000

(U) An initiative in High Power Wide Band Gap Semiconductor Electronics Technology will develop components and electronic integration technologies for high power, high frequency microsystem applications based on wide band gap semiconductors.

(U) Program Plans:
- Develop low defect conducting Silicon Carbide (SiC) substrate consistent with yielding 1 cm^2 devices.
- Develop lightly doped, thick (more than 100 micron) SiC epitaxy with low defects to enable 10 kV class power devices.
- Develop low on-state resistance SiC diodes capable of blocking 10 kV.
- Demonstrate SiC wafer and thick epitaxy with less than 1.5 catastrophic defects per cm^2 consistent with 10 kV reverse blocking.
- Initiate work on Megawatt class SiC power device able to switch at more then100 kHz.
- Initiate work on packaging of high power density, high temperature SiC power electronics.
- Demonstrate megawatt Class SiC power devices.
- Demonstrate high power density packaging for greater than 10 kV operations.
- Develop integrated power control logic compatible with high temperature and power SiC power devices.

	FY 2004	FY 2005	FY 2006	FY 2007
Robust Integrated Power Electronics (RIPE)	(6.660)	3.000	5.286	8.310

(U) The RIPE program will develop new semiconductor materials, devices, and circuits that enable highly compact, highly efficient electronic power converter modules. These new modules will be capable of providing up to 50kW of power per module at a power density of 500W/cubic inch. Based on fundamental material properties, the new power modules will be capable of operating in harsh environments. These new power converters will reduce the launch weight of space-based platforms by hundreds of pounds and will enable new modes of operation where the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

power conversion is done at the point of load and provides high quality power to payloads. Application of RIPE on Naval surface ships would result in a significant reduction of power supply weight; allowing for additional electronic components and/or weapons.

(U) Program Plans:
- Perform concept study to define opportunities for smart power and the potential for integrating silicon carbide, or other wide bandgap semiconductor, with silicon electronics.
- Identify key technical challenges and quantity impact of potential platforms.
- Identify compelling applications.
- Select and optimize wide bandgap materials and processes for smart power circuits.
- Develop integration techniques for silicon carbide, or other wide bandgap semiconductor, onto silicon and/or silicon onto silicon carbide.
- Develop low on-resistance, fast switching silicon carbide power devices with hybrid control electronics.

	FY 2004	FY 2005	FY 2006	FY 2007
UltraBeam	(0.000)	3.087	2.344	2.000

(U) The UltraBeam program involves conversion of femtosecond duration ultraviolet laser light pulses to x-rays and the study of intense x-ray pulse probagation in various media.

(U) Program Plans:
- Validate the scientific feasibility of the conversion and propagation processes.
- Demonstrate a working laboratory model involving higher beam energies and shorter pulse durations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Submillimeter Wave Imaging FPA Technology (SWIFT)	(0.000)	4.100	8.000	13.000

(U) The Submillimeter Wave Imaging FPA (Focal Plane Array) Technology (SWIFT) program will develop revolutionary component and integration technologies to enable exploitation of this spectral region. A specific objective will be the development of a new class of sensors capable of low-power, video-rate, background and diffraction limited submillimeter imaging. This program is utilizing technology developed in the Terahertz Technology Program funded in PE0601101E, Project ES-01.

(U) Program Plans:
- Develop compact, efficient, and high-power THz sources using new electronic and frequency conversion approaches.
- Develop sensitive and large format receiver arrays, advanced integration, and backend signal processing techniques.
- Develop and demonstrate a submillimeter focal plane imager.

	FY 2004	FY 2005	FY 2006	FY 2007
Direct Analog To Target ID - Non-Linear Math for Mixed Signal Microsystems	(0.000)	3.254	3.270	3.286

(U) The principal goal of this program is to demonstrate a significant linearity enhancement capability based upon a digital signal processing approach, implemented in a high performance, very large scale integration (VLSI) chip, that will enable wideband high-dynamic range sensor systems to be developed in a cost effective manner.

(U) Program Plans:
- Develop broadly applicable methodologies for exploiting novel encoding strategies, closed loop adaptive equalization, integration of sensing and processing, and application-specific knowledge in order to provide revolutionary advances in information conversion.
- Explore novel architectures leveraging intelligent pre-processing based upon space, time, and mathematical transformations of analog measurements and employing cooperative integration of analog and digital processing to obtain required system level performance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

- Work with new classes of quantization devices based on novel "error correcting" representations of numbers, such as beta encoders, phase encoders, geometric invariants.

	FY 2004	FY 2005	FY 2006	FY 2007
Integrated Nano-Electronics	(0.000)	0.000	4.000	8.000

(U) The Integrated Nano-Electronics Program will develop a technology for reliably integrating conventional integrated circuits with critical nano-scale devices, such as nanotubes, nanowires, and quantum effect structures. These types of nano-scale devices exhibit operational and physical behaviors based on the fundamental physics of the materials and configurations of the device. Nano-scale technologies can make highly functional devices, with low-loss interconnects and thermal mitigation, resulting in new classes of sensors. Based on their size and physical properties, nano-scale devices can have performance advantages in non-volatile memories, implementation of memory-intensive electronic functions such as image processing, as well as optical and millimeterwave RF sources through plasmon resonances. Also, nano-scale devices can make extremely sensitive physical sensors that can be coupled closely to low power sensor processors. In this program, critical nano-scale materials and process technologies will be developed that are compatible with semiconductor fabrication and can be inserted into a regular design flow. Individual or unstructured masses of nanotubes, nanowires, nanoparticles, and quantum structures are readily fabricated with leading-edge equipment and materials. This program will develop cost-effective technologies for producing bulk materials that are needed as process precursors and will develop the compatible fabrication and integration technologies necessary to create high performance integrated nano-electronic circuits for defense applications, based on exploiting inherent nano-scale device properties with conventional electronics.

(U) Program Plans:

- Develop physical fabrication techniques for nano-scale devices, focusing on establishing core unit processes compatible with an integrated flow.
- Develop efficient simulation techniques and boundary models for static and transient modeling of integrated nano-scale and micro-scale components.
- Demonstrate metrology for measuring critical parameters and functional state variables associated with nano-scale wires and devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Terascale Integration for Scalable Mixed Signal Microsystems	(0.000)	5.000	6.000	10.000

(U) This program will develop semiconductor technologies that provide substantial increases in the integrated performance of entire suites of electronic components that are used for signal generation, detection, and processing, focusing on mixed signal electronics, such as analog/RF/digital chips. This program will result in increased functional densities for highly integrated circuits with low power dissipation, and will pursue innovative nano-scale silicon devices and circuits that will enable precision mixed signal circuits for DoD critical applications.

(U) Program Plans:

- Develop designs for fiber optic connectors that exploit highly integrated (millions of transistors) of nano-scale devices into mixed signal circuits to open up new approaches to creating precision mixed signal systems-on-chip for processing and generating high performance, tailored signals for DoD applications.
- Identify and exploit new device operational modes and chip microarchitectures to allow high performance, low power, and adaptable/reconfigurable circuits and creating an overall design environment that effectively maps complex system problems into efficient silicon IC solutions.

	FY 2004	FY 2005	FY 2006	FY 2007
Radioisotope Micropower Sources	(0.000)	8.392	11.137	13.014

(U) This effort will seek to develop the technologies and system concepts required for safely producing electrical power from radioisotope materials for portable and mobile applications, using materials that can provide passive power generation. There will also be research in compact radioisotope battery approaches that harness MEMS technology to safely and efficiently convert radioisotope energy to either electrical or mechanical power while avoiding lifetime-limiting damage to the power converter caused by highly energetic particles (e.g., such as often seen in previous semiconductor approaches to energy conversion). The goal is to provide electrical power to macro-scale systems such as munitions, unattended sensors, and weapon systems, RF ID tags, and other applications requiring relatively low (up to tens of milliwatts) average power.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:
- Develop and demonstrate core technologies of radioisotopes and the manufacturing of alpha and/or beta capture mechanisms to show advances in power output at high conversion factors, material stability, and particle capture in a small form factor with high conversion efficiencies, while operating within safety considerations and limitations.
- Demonstrate reasonable longevity for the chosen radioisotope-to-electrical or radioisotope-to-mechanical power conversion technique.
- Demonstrate actual, long-lasting power generation by the chosen radioisotope-to-electrical or radioisotope-to-mechanical conversion method.

	FY 2004	FY 2005	FY 2006	FY 2007
3-D Directed MicroAssembly	0.000	0.000	2.000	4.000

(U) This research program will develop novel technologies for the rapid and automated directed assembly of large numbers ($> 10^6$) of prefabricated micron-scale parts into three dimensional meso-scale (millimeter to meter sized) multifunctional active structures and robotic systems. Using these technologies will allow fabrication of structures comprised of individual components with mechanical, sensory, and computational capabilities that perform complex functions (much as biologically produced structures do) of military interest.

(U) Program Plans:
- Exploit innovative ideas in fluidic self-assembly and massively parallel microactuator systems.
- Explore both industry and university work on precise “pick and place” operations on large numbers of components.
- Demonstrate the capability to (1) select and position parts based upon their location in a 3-D structure, (2) bond/weld the parts into position, and (3) establish interconnects as required to provide for internal communication and power.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Universal Photonic Interface for High Dynamic Range Antenna (U-PHO)	(0.000)	0.000	6.000	8.000

(U) The goal of this program is to develop photonic transmitter modules that can adapt their frequency response and dynamic range characteristics to mate with the full spectrum of narrow-band and broadband microwave transmission applications covering the 2 MHz – 20 GHz range. These field programmable, real-time adaptive photonic interface modules will find application in high dynamic range communications, radar and EW antenna applications.

(U) Program Plans:

- Integrate to allow tunable frequency and impedance matching to arbitrary antenna structures, with adaptive pre-distortion, feedback and feed-forward linearization schemes to achieve >135 dB SFDR (1 Hz).
- Transition into airborne, space and maritime platforms where wideband communications, radar and EW apertures, with size, weight and power advantages are needed.

	FY 2004	FY 2005	FY 2006	FY 2007
Polymorphous Computing Architecture (PCA)	(15.015)	23.056	10.938	10.020

(U) The Polymorphous Computing Architectures (PCA) program is developing a revolutionary approach to the implementation of embedded computing systems to support reactive multi-mission, multi-sensor, and in-flight retargetable missions. This revolutionary approach will also reduce payload adaptation, optimization and verification process from years down to minutes. Current DoD embedded computing systems can be characterized as static in nature, relying on hardware-driven, heterogeneous point-solutions that represent static architectures and software optimizations. The program breaks the current development approach of hardware first and software last by moving beyond conventional silicon to flexible polymorphous computing systems. The key efforts of this revolutionary step forward in embedded computing systems are: 1) define critical reactive computing requirements and critical micro-architectural features; 2) explore, develop and prototype reactive polymorphous computing concepts; 3) explore, develop and prototype multi-dimensional verification and validation techniques for dynamic reactive missions; and 4) provide early experimental testbeds and prototype polymorphous computing systems; and 5) extend PCA to enable early commercial

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

product development and transition to the DoD and intelligence communities. The result will be a new generation of on-board, embedded computing processing capability that will be mission and technology invariant yet highly optimizable for each new mission scenario. This processing capability will provide tactical and strategic mission tempo opportunities as well as technical upgradeability over the life of the computing system. Based on an average of four major upgrades over a 30 year period, significant savings of up to 45 percent in development and deployment costs may now be achieved over the life of a typical DoD embedded computing system. The program will also develop interactive, real-time terrain computation, visualization and manipulation to support Computer Generated Forces (CGFs), specifically the OneSAF (One Semi-Automated Forces). This effort will leverage commercial graphic processing units (GPU) and early PCA program streaming technology to provide key technology transitions.

(U) Program Plans:

- Develop multi-dimensional reactive computing optimization, verification techniques.
- Model, simulate and characterize complete candidate polymorphic computing systems including hardware elements, morphware, run-time systems and tools.
- Perform early small scale proof-of-concept testing, integration and evaluation of early polymorphic computing architecture prototypes.
- Demonstrate and quantify the potential of full up polymorphic computing architecture systems for the DoD and their complementary commercial viability.
- Select, develop, and perform a DoD risk reduction effort for a multi-mission application.
- Set the stage for technology transition to commercial and Defense contractor communities in support of DoD applications.
- Perform early commercial product development and transition to the DoD and Intelligence on-board embedded processing communities.
- Develop and demonstrate line-of-sight and collision computations using GPU.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Antimonide Based Compound Semiconductors (ABCS)	(10.346)	0.000	0.000	0.000

(U) This program worked to develop low power high frequency electronics circuits and infrared (IR) sources based on the Antimonide family of compound semiconductors (ABCS). Specific IR source goals included operating above thermoelectric cooled temperatures and greater than 10 percent efficiency with continuous wave (cw) in the Mid-Wave Infrared (MWIR) and single mode cw operation in the Long-Wave Infrared (LWIR).

(U) Program Plans:

- Substrate Technology. Accelerated recent breakthroughs in lateral epitaxial overgrowth and thin film delaminating and rebonding to develop a source for ABCS substrates with essentially any desired thermal and/or electronic property.
- Electronics Integration. Raised levels through a series of demonstrations of analog, digital or mixed signal circuits with increasing device count which have beyond state-of-the-art performance in terms of frequency of operation and low power consumption.
- Demonstrated robust semi-insulating ABCS substrate material.
- IR sources. Exploited the unique bandgap engineering approaches available with the ABCS family of materials to increase the operation temperature above 230 degrees Kelvin and extend emission over the Long-Wave Infrared (LWIR) range.
- Achieved multi-watt output, array technology along with increases in efficiency for individual devices.
- Delivered first six multi-batch ABCS substrates.

	FY 2004	FY 2005	FY 2006	FY 2007
Integrated Mixed Signal (A/D) and Electronic/Phototonic Systems (NeoCAD)	(10.336)	0.000	0.000	0.000

(U) The Integrated Mixed Signal (A/D) and Electronic/Photonic Systems (NeoCAD) program strived to develop and demonstrate innovative approaches to Computer Aided Design (CAD) of Mixed Signal (Analog/Digital) and Mixed Electronic/Photonic systems. The goal: to enable the design and prototyping of ultra complex microsystems with a high degree of integration and complexity for both military and commercial applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:

- Developed Model Order Reduction methods (for analog and photonic devices) to enable the creation of behavioral models.
- Developed and demonstrated top-down design capabilities for analog, mixed signal and mixed electronic/photonic systems that match the efficiency currently achieved with digital designs.
- Developed fast solvers for analog and photonic devices; performed non-linear model order reduction, developed extraction tools, synthesized capabilities for mixed signal and mixed electronic/photonic circuits, and developed interfaces with existing digital tools to enable co-simulation.
- Demonstrated the tools for designing and prototyping selected mixed electronic/photonic circuits and mixed signal systems (e.g., Analog-to-Digital Converters) for military applications.
- Developed a design methodology for analog, mixed signal and mixed electronic/photonic systems utilizing:
  - -- Analog behavioral models in a digital design environment.
  - -- Extraction methodologies for analog and photonic devices.
  - -- Synthesis and layout rules for analog and photonic devices.
  - -- Hierarchical design libraries.

	FY 2004	FY 2005	FY 2006	FY 2007
Moletronics	(13.330)	0.000	0.000	0.000

(U) The molecular electronics (Moletronics) program pursued the concept that integration of multiple molecules, nanotubes, nano-wires, etc., into scalable, functional devices that are interconnected to the outside world would enable lower power operation, a wide range of operating temperatures and much greater device density. This research also demonstrated the scalability of molecular scale electronics to circuits containing 10^{11} elements and for densities equivalent to $10^{11}/cm^2$ and show that hierarchical self-assembly processes can be employed to build molecular circuits. The technologies explored in the Moletronics program formed the basis for the on-going Applications of Molecules Electronics program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:
- Characterized and optimized molecular-based devices such as switches, multi-state molecules and molecules exhibiting highly non-linear characteristics such as negative differential resistance.
- Demonstrated that nano-wires have conductivities near that of bulk metal or better.
- Quantified the defect-tolerance required for a molecular-based computer to still function.
- Developed hierarchically directed assembly processes to assemble molecular devices, wires and interconnects.
- Demonstrated efficient defect-search algorithms.
- Modeled the scalability of molecular circuit architectures to high counts and high device densities.

	FY 2004	FY 2005	FY 2006	FY 2007
Applications of Molecular Electronics (MoleApps)	(11.120)	4.608	10.020	10.110

(U) The goal of the MoleApps program is to extend the capabilities being developed in the current Moletronics program to demonstrate the computational processing capabilities of molecular electronics in a system that integrates memory with control logic and data paths. A demonstration processor will be designed and built that can interpret a simple high-level language. This approach will allow the use of simpler processor designs to demonstrate the advantages of nano-scale molecular electronics that do not have the conventional circuitry overhead associated with modern pipeline chip designs.

(U) Program Plans:
- Construct combinatorial logic functions assembled from molecular-scale components.
- Use small-scale integration (SSI) to build combinatorial logic functions using molecular-scale components.
- Construct sequential logic/finite-state machine assembled from molecular-scale components.
- Add registers or latches in communication with combinatorial logic arithmetic functions.
- Use medium-scale integration (MSI) to construct sequential logic/finite-state machine assembled from molecular-scale components.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Quantum Information Science and Technology (QuIST)	(27.692)	25.437	0.000	0.000

(U) The Quantum Information Science and Technology (QuIST) program will explore all facets of the research necessary to create a new technology based on quantum information science. Research in this area has the ultimate goal of demonstrating the potentially significant advantages of quantum mechanical effects in communication and computing. Expected applications include new, improved forms of highly secure communication, faster algorithms for optimization in logistics and wargaming, highly precise measurements of time and position on the earth and in space, and new image and signal processing methods for target tracking. Technical challenges include loss of information due to quantum decoherence, limited communication distance due to signal attenuation, limited selection of algorithms and protocols, and scalability to large numbers of bits. Error correction codes, fault tolerant schemes, and longer decoherence times will address the loss of information. Signal attenuation will be overcome by exploiting quantum repeaters. New algorithm techniques and complexity analysis will increase the selection of algorithms, as will a focus on signal processing. Scalable solid-state technologies will integrate thousands of qubits on a single device. Expected impacts include highly secure communications, algorithms for optimization in logistics and wargaming, highly precise measurements of time and position on the earth and in space, and new image and signal processing methods for target tracking. Additionally, QuIST will also pursue technologies to build and demonstrate a scalable quantum information processor that will address issues such as architecture and manufacturability. The computing technologies developed in QuIST are being continued and applied in the Focused Quantum Systems program. Additionally, quantum technologies for secure communications will be further developed in another program.

(U) Program Plans:

- Refine quantum architecture and design solutions for problems such as graph isomorphism, imaging, and signal processing.
- Investigate alternative protocols for secure quantum communication, quantum complexity, and control.
- Integrate improved single and entangled photon sources and detectors into existing quantum communication networks.
- Investigate alternative designs, architectures and devices for quantum communication, computation, and memory; demonstrate high-rate (1 Gbit/sec) quantum-secure communication over a single link; transition quantum-secure communication to existing DoD mobile testbed.
- Employ scalable qubit architectures to demonstrate an application of interest to the DoD (e.g., quantum repeater, secure metropolitan-area network).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Focused Quantum Systems (FoQuS)	(0.000)	13.753	24.703	24.110

(U) The FoQuS program will develop a path toward an advanced quantum information processor drawing on the fundamental understanding and foundations developed under the QuIST program which is also funded in this project. Key elements for such a processor include architectural development, quantum memory, input/output (I/O) interfaces, state synthesizers, and nanofabrication of materials and devices. The specific goal of the program is to significantly accelerate the development of a quantum computer, with the aim of building a quantum information processor in a decade rather than a score of years, as projected by the current roadmap.

(U) Program Plans:
- Develop solid state and other potentially scalable technologies.
- Leverage substantial investment already made by semiconductor industry in materials infrastructure.
- Develop industry participation to provide the discipline necessary for ultimate manufacturability of a quantum processor.

	FY 2004	FY 2005	FY 2006	FY 2007
CAD-QT (Cognitively Augmented Design for Quantum Technololgy)	0.000	0.000	2.320	0.000

(U) Develop and demonstrate revolutionary robust optimization-based methodology for the design of electronic and photonic devices whose novel functional capabilities derive from operation within the quantum regime. This program will transform the device designer's art from its current intuition-based ad-hoc exploitation of quantum effects, which provides at best incremental advances in suboptimal devices. CAD-QT will replace this with computational design tools amplifying the designer's experience and capability for systematic exploration of complex multi-physics systems. Use of these tools is expected to dramatically reduce the time and expense required to create practical devices and systems which optimally harness quantum effects to obtain desired function.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:
- Validate CAD-QT system by employing it to design optoelectronic modulator devices performing significantly beyond the current state of the art.
- Investigate the exploitation of new fields of nanophotonics and plasmonics, in which metal nanostructures convert electromagnetic radiation into charge density waves.

	FY 2004	FY 2005	FY 2006	FY 2007
Solid State Imager/Extended Range Materials	(0.000)	0.000	5.000	10.000

(U) Imaging in the near-to-mid wave spectral region provides the capability to penetrate atmospheric obscurants and image where conventional sensors cease to generate data or produce severely degraded information. New materials and concepts for solid state imaging are essential to take advantage of this novel imaging regime, providing the capability to see where others cannot. This development includes new material concepts, such as quantum dots and superlattice structures, which offer the ability to precisely tailor the spectral band, and potentially operate at or near room temperature. In addition, new solid state sensor concepts will be developed to spatially and temporally co-register each pixel in the image to implement novel on-chip processing for noise cancellation and clutter rejection in severely degraded environments.

(U) Program Plans:
- Develop new material concepts.
- Develop new solid state sensors concepts.

	FY 2004	FY 2005	FY 2006	FY 2007
Advanced Microsystems Technology Program	(0.000)	5.000	5.000	5.000

(U) This program will explore a range of advanced microsystem concepts well beyond existing current technologies. The program will focus on technologies that exploit three dimensional structures, new materials for Gieger mode detectors, advance patterning, and extreme scaling in silicon devices. Insights derived in these areas will be exploited in future program initiatives.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

(U) Program Plans:
- Establish and exercise multi-project wafer runs for 3D integrated circuits.
- Demonstrate bonding and functionality of SOI circuits to InP detectors.
- Extend maskless multiple exposure system to 2x smaller features.
- Demonstrate photoresist capable of multiple in-situ exposure with enhanced resolution.
- Demonstrate sub-35 nm half-pitch interometric liquid exposure capability.
- Prepare report analyzing prospects for beyond roadmap technologies.
- Deliver data on ultra-low voltage operation of Si CMOS for DoD applications.

	FY 2004	FY 2005	FY 2006	FY 2007
HyperX	(0.000)	0.000	3.500	10.000

(U) Many Department of Defense (DoD) systems require processing and analysis of vast amounts of high-dimensional data in the field. The HyperX program will provide the capability for high performance signal processing at significantly lower power in a reconfigurable architecture. The focus of the program is to provide the military with a reconfigurable integrated circuit technology that can achieve high performance application-specific real time signal processing at low enough power to be suitable for embedded applications. In these cases, where severe constraints on power preclude the use of general purpose processing solutions, HyperX chips will provide more than an order of magnitude (10x) increase in both power and throughput performance over the current state-of-the-art reconfigurable Field Programmable Gate Array (FPGA) and general programmable processors.

(U) Program Plans:
- Demonstrate a novel, reconfigurable IC with significant improvement over current programmable and reconfigurable IC technology.
- Verify performance of HyperX IC fabric (operate at $\geq$ 500MHz and consume $\leq$ 250milliwatts).
- Develop Integrated Hardware/Software Design Environment Software.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Energy Starved Electronics (ESE)	(0.000)	0.000	3.495	10.000

(U) The Energy Starved Electronics (ESE) program seeks to develop ultra low power IC devices and circuit design methods for military electronics that must operate where power is severely limited. The objective of the program is to mature both device technology and design techniques to allow operation of devices in the subthreshold (very low voltage) regime beyond where the circuit devices normally operate. The ability to operate an ultra-low power circuit while still maintaining modest performance will enable the successful implementation of many long lived operational systems such as remote sensor networks as well as small unit communications and other wireless applications. The goal of the program will be a 100X improvement in energy per operation over conventional designs operated at low voltage.

(U) Program Plans:

- Develop a robust design methodology and sub-threshold standard cell library.
- Implement a feedback control scheme to achieve operation at the minimum energy dissipation point.
- Demonstrate ultra-dynamic voltage scaling methodology that allows performance and energy to be traded-off over several orders of magnitude.
- Develop and demonstrate fault-tolerant methodology for digital circuits to minimize effects of process variations and small signal margins.
- Explore architectures to minimize the power dissipation of circuits in sub-threshold operation while keeping performance constant.
- Establish fundamental limits of energy dissipation of digital circuits taking into account process variations and device impairments (e.g., leakage).
- Identify and enhance the process/device technology that provides highest performance, lowest leakage circuits for operation at < 300mV.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Optical Arbitrary Waveform Generation (AWG)	0.000	0.000	6.000	10.000

(U) The ultimate vision for the Optical Arbitrary Waveform Generator (AWG) program is to demonstrate a compact, robust, practical, stable octave-spanning optical oscillator, and to demonstrate the ability to independently encode/decode (both via amplitude and phase modulation) all individual frequency components of such an octave-spanning oscillator with an update rate approaching the mode-locked repetition rate. This would provide an unprecedented level of performance for optical systems, and enable numerous high level applications, including sub-diffraction-limited imaging and ultra-wideband optical communications.

(U) Program Plans:
- Demonstrate technology for producing (and detecting) arbitrary optical waveforms with fractional bandwidths approaching 10.
- Demonstrate system applications of Optical AWGs that are of high military interest.

	FY 2004	FY 2005	FY 2006	FY 2007
Fabrication of 3D Structures/Characterization, Reliability, & Application	(2.000)	1.800	0.000	0.000

(U) The goal of the Fabrication of Three Dimensional Structures program is to investigate multi-chip module technology.

(U) Program Plans:
- Continued the development of key technologies behind a packaging concept that uses a stacked multi-chip module approach to reduce interconnect length and increase physical connectivity between layers of electronics.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Center for Optoelectronics and Optical Communications	(2.500)	5.000	0.000	0.000

(U) The Center for Optoelectronics and Optical Communications program is investigating advances in optical communications.

(U) Program Plans:
- Continued optoelectronic and optical communications development.

	FY 2004	FY 2005	FY 2006	FY 2007
NanoElectronics Defense and Security Initiative	(0.000)	1.500	0.000	0.000

(U) Program Plans:
- Develop cryo-electronic components for use in large military power systems. The initial focus is on Navy Ship Power Conversion.

	FY 2004	FY 2005	FY 2006	FY 2007
Nanoscale Organic Spintronics	(0.000)	1.400	0.000	0.000

(U) Program Plans:
- Synthesize and charaterize organic compounds for solid state devices using electronic spins and construct solid state devices from 2 and 3 qubit molecular systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

	FY 2004	FY 2005	FY 2006	FY 2007
Nano Photonic Systems Fabrication	(1.000)	0.000	0.000	0.000

(U) This program focused on the development of new materials for nano-optics.

(U) Program Plans:
- Prepared new materials for applications in lasers and nano-inspired optics.
- Enhanced nano-photonic systems fabrication capabilities for DoD by concentrating on unique technologies for photonic device fabrication, integration and packaging.

	FY 2004	FY 2005	FY 2006	FY 2007
Integrated Nano and Micro-manufacturing	(1.000)	0.000	0.000	0.000

(U) This program sought to develop new nano and micro-manufacturing technologies.

(U) Program Plans:
- Initiated development of advanced nano and micro-manufacturing technologies.

	FY 2004	FY 2005	FY 2006	FY 2007
Testing & Evaluation of Advanced Composites	0.000	1.400	0.000	0.000

(U) This program will initiate development of testing and evaluation processes for advanced composite materials.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2005
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1 # 20

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

	FY 2005	FY 2006	FY 2007
Previous President's Budget	252.708	239.588	254.860
Current Budget	261.406	241.736	249.453
Total Adjustments	8.698	2.148	-5.407

Please note that this program element was established in accordance with congressional intent in FY 2005. FY 2004 and prior was funded under PE 0602712E. The Previous President's Budget amounts reflect projects MPT-02 and MPT-08.

Congressional program reductions	-2.402
Congressional increases	11.100
Reprogrammings	0.000
SBIR/STTR transfer	0.000

(U) **Change Summary Explanation:**

FY 2005 Increase reflects congressional adds for five electronics programs offset by congressional undistributed reductions.
FY 2006 - 2007 Changes reflect minor repricing.

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

- Not Applicable.