Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency										DATE: February 2010	
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*				R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*							
COST ($ in Millions)	**FY 2009 Actual**	**FY 2010 Estimate**	**FY 2011 Base Estimate**	**FY 2011 OCO Estimate**	**FY 2011 Total Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	181.519	179.402	286.936	0.000	286.936	348.377	327.984	347.871	347.534	Continuing	Continuing
ELT-01: *ELECTRONICS TECHNOLOGY*	181.519	179.402	286.936	0.000	286.936	348.377	327.984	347.871	347.534	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

(U) Advances in microelectronic device technologies, including digital, analog, photonic and MicroElectroMechanical Systems (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 for 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. This project has five major thrusts: Electronics, Photonics, MicroElectroMechanical Systems, Architectures, Algorithms, and other Electronic Technology research.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	199.396	223.841	0.000	0.000	0.000
Current President's Budget	181.519	179.402	286.936	0.000	286.936
Total Adjustments	-17.877	-44.439	286.936	0.000	286.936
• Congressional General Reductions		-0.752			
• Congressional Directed Reductions		-65.687			
• Congressional Rescissions	-2.092	0.000			
• Congressional Adds		2.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-10.183	0.000			
• SBIR/STTR Transfer	-5.602	0.000			
• Congressional Restoration for New Starts	0.000	20.000	0.000	0.000	0.000
• TotalOtherAdjustments	0.000	0.000	286.936	0.000	286.936

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2009	FY 2010
Project: ELT-01: *ELECTRONICS TECHNOLOGY*		
Congressional Add: *3-D Technology for Advance Sensor Systems*	1.440	2.000
Congressional Add: *Secure Media and ID Card Development*	0.240	0.000
Congressional Add Subtotals for Project: ELT-01	1.680	2.000
Congressional Add Totals for all Projects	1.680	2.000

Change Summary Explanation

FY 2009

Decrease reflects transfer of the "Indium Base Nitride Technology Development" congressional add within RDT&E Defense-Wide, Section 8042 rescission of FY 2010 Appropriations Act, SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts offset by congressional adds (as identified above) and FY 2010 Congressional Restoration for New Starts.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

FY 2011
Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Advanced Microsystems Technology Program	5.000	5.000	5.000	0.000	5.000
(U) The Advanced Microsystems Technology program explores a range of advanced microsystem concepts well beyond existing current technologies. The program focus is on technologies that exploit 3-Dimensional (3-D) 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. *FY 2009 Accomplishments:* - Prepared report analyzing prospects for beyond roadmap technologies. - Delivered data on ultra-low voltage operation of Silicon Complimentary Metal Oxide Semiconductor (CMOS) for DoD applications. *FY 2010 Plans:* - Demonstrate midwave IR (MWIR) photon-counting arrays using antimonide-based avalanche photodiodes. - Demonstrate nanolithography techniques which enable use of electron-beam lithography in conjunction with interferometric optical patterning or templated self-assembly. *FY 2011 Base Plans:* - Demonstrate focal planes using dense monolithic 3-D integration of silicon electronics and compound semiconductor detectors. - Demonstrate ultralow-power silicon CMOS technology optimized for DoD applications such as space electronics, long endurance microsensors, and extreme temperature electronics.					
High Frequency Wide Band Gap Semiconductor Electronics Technology	15.564	14.108	20.320	0.000	20.320

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The overall objective of the High Frequency Wide Band Gap Semiconductors Electronic Technology initiative is to fully exploit the properties of wide bandgap semiconductors (WBGS) to enhance the capabilities of microwave and millimeter-wave (MMW) monolithic integrated circuits (MMICs) and in turn, enable future RF sensor, communication, and multifunction military capabilities. The program will also develop revolutionary nitride transistor technology that simultaneously provides extremely high-speed and high-voltage swing [Johnson Figure of Merit larger (JFoM) than 5 THz-v] in a process consistent with large scale integration in enhancement/depletion (E/D) mode logic circuits of 1,000 or more transistors. In addition, this fabrication process will be manufacturable, high-yield, high-uniformity, and highly reliable. Wide bandgap semiconductors have the ability to deliver very high-power and other very favorable high frequency characteristics. Prior efforts have focused on improvements to the basic semiconductor while current efforts are focused on realizing devices and circuits. These technologies will lead to affordable, high performance, reliable, wide bandgap devices and MMICs with characteristics suitable for enabling new DoD systems and greatly improved performance for fielded platforms. *FY 2009 Accomplishments:* - Identified thermal management concepts to sustain more than 1 KW/cm squared power density in high-power devices. - Optimized wide bandgap semiconductor materials to achieve 100 mm substrates with less than 10 micropipe/cm squared and resistivity greater than 10^7 ohms-cm at room temperature. - Demonstrated fabrication processes for robust microwave and mm-wave devices with radio frequency yields greater than seventy percent. - Demonstrated thermal management concepts to sustain more than 1 KW/cm squared power density in high power device. - Developed processes that enabled highly scaled Enhancement-mode (E-mode) and Depletion-mode (D-mode) operation High Electron Mobility Transistor devices.					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop and utilize physics-based models that accurately predict device performance. - Demonstrate reproducible WBGS device and MMICs fabrication processes. - Demonstrate WBGS devices and MMICs that, while maintaining high levels of producibility and reliability, achieve substantially higher levels of performance compared to GaAs-based microwave and MMW devices and MMICs. - Demonstrate superior thermal management and packaging strategies. - Develop self-aligned structure with short gate length, novel barrier layers and reduced parasitics. - Demonstrate technologies to achieve circuits of significant complexity (~1,000 transistor devices or more). - Develop transistor models. *FY 2011 Base Plans:* - Develop high-performance Gallium Nitride Field Effect Transistors (FET). - Optimize transistor performance. - Achieve yield to enable modest integration levels.					
Quantum Information Science (QIS) (U) The Quantum Information Science (QIS) program will explore all facets of the research necessary to create new technologies 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 larger numbers of bits. Error correction codes, fault tolerant schemes,	7.985	6.200	5.450	0.000	5.450

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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. The QIS program is a broad-based effort that will continue to explore the fundamental open questions, the discovery of novel algorithms, and the theoretical and experimental limitations of quantum processing as well as the construction of efficient implementations. *FY 2009 Accomplishments:* - Investigated unresolved fundamental issues related to quantum information science. - Employed qubit architectures to demonstrate applications of interest to the DoD (e.g., quantum repeater, secure metropolitan-area network). - Demonstrated interoperation between multiple qubit types to interconnect quantum communications links. *FY 2010 Plans:* - Measure single electron spin lifetime and demonstrate controlled gate operations in gated quantum dots (QD) in silicon (Si). - Conduct theoretical analysis of improvement in decoherence time resulting from dynamical decoupling schemes. - Explore novel materials, noise characteristics and decoherence mitigation strategies for superconducting qubits. *FY 2011 Base Plans:* - Measure single electron spin decoherence time in gated QD in Si. - Demonstrate entanglement swapping protocol in three QD devices in Si. - Perform state tomography and dispersive readout for one and two superconducting qubits. - Fabricate high quality superconducting tunnel junctions through material improvement.					
Feedback-Linearized Microwave Amplifiers	5.885	2.650	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) Modern military platforms require increased dynamic range receivers for their onboard communications in both radar and electronic warfare antenna systems. The goal of the Feedback-Linearized Microwave Amplifiers program is to develop radio frequency (RF) amplifiers with revolutionary increased dynamic range receivers through the use of linear negative feedback. This program will develop the core technologies and components that may be used as building blocks and/or modules in future system applications. *FY 2009 Accomplishments:* - Developed and enhanced Indium Phosphate (InP) Hetrojunction BiPolar Transistor (HBT)-based RF operational amplifier and InP High Electron Mobility Transistor (HEMT)-based ultra-low-noise amplifier. *FY 2010 Plans:* - Demonstrate feedback-linearized all-HBT monolithic low-noise amplifier with improved third-order-intercept point and noise factor. - Demonstrate feedback linearized InP HEMT monolithic low-noise amplifier. - Establish packaging technology for composite low-noise amplifier module.					
Terahertz Electronics (U) Terahertz Electronics will develop the critical semiconductor device and integration technologies necessary to realize compact, high-performance microelectronic devices and circuits that operate at center frequencies exceeding 1 Terahertz (THz). There are numerous benefits to operating in the THz regime and multiple new applications in imaging, radar, communications, and spectroscopy, all enabled by electronics that operate in the THz frequency regime. The Terahertz Electronics program is divided into two major technical activities: Terahertz Transistor Electronics that includes the development and demonstration of materials and processing technologies for transistors and integrated circuits for receivers and exciters that operate at THz frequencies; and Terahertz High Power Amplifier (HPA) Modules that includes the development and demonstration of device and processing technologies for high power amplification of THz signals in compact modules.	12.256	13.980	17.720	0.000	17.720

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed devices and circuits for candidate applications with demonstration of operation at a frequency of at least 0.67 THz. - Demonstrated 18dBm power amplification at 0.67 THz. *FY 2010 Plans:* - Develop devices and circuits for candidate applications with demonstration of operation at a frequency of at least 0.85 THz. - Demonstrate 14dBm power amplification at 0.85 THz. *FY 2011 Base Plans:* - Achieve key device and integration technologies to realize compact, high performance electronic circuits operating beyond 1 THz.					
Carbon Electronics for RF Applications (CERA) (U) The Carbon Electronics for RF Applications (CERA) program will develop a wafer-scale graphene (2-Dimensional carbon monolayer) synthesis process resulting in films with excellent mobility, uniformity and layer control (down to single monolayer films). These carbon films will then be used to develop ultra-low power, high-speed field effect transistors optimized for RF-applications (RF-FET). The program will conclude with a demonstration of a low power, low noise amplifier (LNA) using graphene-field effect transistors (FETs) as the channel material. *FY 2009 Accomplishments:* - Developed synthesis process for wafer-scale graphene thin films. - Demonstrated feasibility of graphene channel based FETs. *FY 2010 Plans:* - Optimize synthesis process for wafer-scale graphene thin films.	10.032	7.898	6.958	0.000	6.958

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Optimize RF-FETs based on graphene channels. *FY 2011 Base Plans:* - Increase area of graphene synthesis to wafer-scale dimensions. - Demonstrate film thickness control down to single monolayer. - Demonstrate low power, high performance RF-FETs with graphene. - Demonstrate initial wide-band LNA using graphene channel based RF-FETs.					
Compound Semiconductor Materials On Silicon (COSMOS) (U) The objective of the Compound Semiconductor Materials On Silicon (COSMOS) program is to develop a robust semiconductor fabrication technology and manufacturing process for the intimate integration of multiple types of devices and semiconductor materials. Conventional semiconductor processing is limited to one type of semiconductor but most DoD systems have circuits with multiple types of semiconductor circuits and devices. This program is developing heterogeneous material and device fabrication technologies to allow compound semiconductors to be directly integrated with standard silicon. The high yield fabrication approaches will allow the various materials to be in close proximity. This program is also focusing on innovations in design to ensure that the resulting composite circuits realize superior performance in advanced circuit demonstrations. *FY 2009 Accomplishments:* - Fabricated wafers using the COSMOS process. - Evaluated alignment and bonding methods to achieve mechanical integrity of dissimilar materials, post-processing compatibility with complimentary metal-oxide semiconductor (CMOS), and the achievement of high fabrication yields. - Extended the capabilities of wide bandgap devices for use in power amplifiers (PAs) at frequencies at least as high as X-band and to make this technology useful at very high frequencies. - Demonstrated large (greater than 1 mm) devices.	14.760	10.834	9.116	0.000	9.116

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Decreased the number of optical phonons in the critical gate region of radio frequency (RF) PA devices. *FY 2010 Plans:* - Increase the density of heterogeneous interconnections between compound semiconductors and silicon. - Implement process enhancements to improve the yield of the heterogeneous interconnect process. - Complete design of an advanced mixed-signal circuit demonstrator such as a heterogeneously-integrated 13-bit digital-to-analog converter. *FY 2011 Base Plans:* - Complete design of a complex mixed signal circuit demonstration vehicle, such as a heterogeneously-integrated 16-bit analog-to-digital converter. - Implement the COSMOS process to demonstrate that fine-scale heterogeneous integration can be realized on a large-scale circuit and that the performance benefits can be realized.					
Steep-subthreshold-slope Transistors for Electronics with Extremely-Low Power (STEEP) (U) The Steep-subthreshold-slope Transistors for Electronics with Extremely-low Power (STEEP) program goal was to develop revolutionary transistor technologies, which enabled devices to be operated at voltages as low as 0.2 V without loss in performance (defined by available drive current). The approach was to develop novel transistors with sub-threshold “turn-on” slopes as sharp as 20 millivolt (mV)/decade while maintaining excellent current drive characteristics. This program mainly focused on developing band-to-band tunneling transistors that will be operated at low bias voltages with high saturation current and low leakage current. In addition, associated device models were developed in the program to enable novel ultra-low power circuit designs. At the end of the program, complex demonstration circuits achieved significant power savings, both active and standby, of at least twenty-five times. The STEEP transistors utilized the mechanism of gate controlled modulation of the energy band alignment between the conduction and valence bands of a band-to-band-tunneling device. The	4.218	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
key technical challenges of the program included (1) achieving steep sub-threshold slope over many decades of current, (2) developing CMOS compatible fabrication flow, (3) developing novel circuit designs accommodating asymmetric source-drain doping, (4) demonstrating abrupt doping profiles at tunneling junctions, and (5) integrating silicon-germanium (SiGe), germanium (Ge), or group III-V material in the transistor structures to facilitate the required tunneling currents. The STEEP program started with the development of transistors with less than 30mV/dec of sub-threshold slope and then proceeded to demonstrate the integration of these devices into logic circuits using an eight inch wafer technology. Finally, the STEEP program focused on the yield improvement of a complex ultra-low power static random access memory (SRAM) circuit. *FY 2009 Accomplishments:* - Developed associated device models of band-to-band tunneling transistors. - Engineered transistor structures and began fabrication of key device modules capable of meeting performance milestones of low power consumption and good performance.					
Leading Edge Access Program (LEAP) (U) The Leading Edge Access Program (LEAP) is a companion effort to the STEEP program and its focus is to enable university, industry, and government lab access to on-shore state of the art Complementary Metal Oxide Semiconductor (CMOS) technology for the purpose of performing advanced integrated circuit (IC) research of benefit to the DoD. Specifically, LEAP intends to offer foundry access at a substantially reduced cost for CMOS technology nodes of 45 nanometers (nm) and below. Currently much of the IC design work performed using advanced technology nodes, including that done for the DoD, uses off-shore facilities in Asia and Europe. This results in substantial intellectual property (IP) development outside the U.S. and creates a number of difficulties for technology transition of DoD-critical applications. This program will stimulate U.S.-based advanced design research, providing top researchers early and partially subsidized access to validate and test innovative ideas and facilitate a more natural transition of pioneering ideas.	1.000	3.210	3.210	0.000	3.210

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Began research in 45 nm silicon on insulator (SOI). *FY 2010 Plans:* - Initiate transition of 45 nm SOI to 32 nm bulk CMOS. *FY 2011 Base Plans:* - Transition to 32 nm SOI, 22 nm bulk CMOS, and 22 nm SOI.					
High Frequency Integrated Vacuum Electronic (HiFIVE) (U) The objective of the High Frequency Integrated Vacuum Electronic (HiFIVE) program is to develop and demonstrate new high-performance and low-cost technologies for implementing high power millimeterwave sources and components. This program is developing new semiconductor and micro-fabrication technologies to produce vacuum electronic (VE) high-power amplifiers (HPAs) for use in high-bandwidth, high-power transmitters. Innovations in design and fabrication are being pursued to enable precision etching, deposition, and pattern transfer techniques to produce resonant cavities, electrodes, and magnetics, and electron emitting cathodes for compact high-performance millimeter wave devices. These new technologies will eliminate the limitations associated with the conventional methods for assembly of high-power sources in this frequency range. *FY 2009 Accomplishments:* - Validated cold test interaction of structure design and high current density cathodes. - Explored/identified novel material to optimize circuit performance characteristics. *FY 2010 Plans:* - Validate the design of a high power amplifier through experiments and computational simulation. - Complete development of the high-performance cathode prototype and demonstrate its ability to operate without degradation for at least 1000 hours.	11.876	8.430	11.120	0.000	11.120

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete advanced cathode development activities. - Complete fabrication and initial testing of a high power amplifier prototype device incorporating HiFIVE micro-fabrication technologies. - Initiate efforts to perform laboratory measurements of performance.					
Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF)	5.287	1.298	0.000	0.000	0.000
(U) The Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF) program will increase the tuning speed of high-temperature semiconducting (HTS) filters, from about a second with present mechanical methods, to microsecond speeds required for systems such as the Joint Tactical Information Distribution System (JTIDS). The technology for such a million-fold improvement relies upon semiconductor tuning, properly mated with the superconducting filter materials; the fundamental challenge – that normal electrical conductivity and superconductivity cannot coexist in the same circuit – has been overcome. In addition to interference-rejection at microsecond speeds, these filters make it possible to perform wide spectral searches with unprecedented frequency resolution, enabling detection of very weak emissions (signatures) characteristic of threat systems. Such a capability within a small add-on box to the RF receiver, will revolutionize the performance of all types of receivers, with applications ranging from communications to signals intelligence, and enable operation in the densest of interference environments.					
FY 2009 Accomplishments: - Designed and demonstrated the capability for a usable tunable-superconducting filter bank system within the frequency range 400 - 3,000 MHz, with multiple sub-bands each tunable to about 20% of the mean range. The minimum bandwidth requirement is 5 MHz (consistent with a fractional bandwidth of 0.5% at 1 GHz). The prior accomplishments for filter switching time, insertion loss and out-of-band rejection were maintained.					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Evolve a concept for a front-end pre-selector filter bank, consisting of both tunable notch and bandpass filters, which would demonstrate the capability of removing local interference, particular those agile signals such as JTIDS. - Construct a pre-selector module, incorporating HTS filters and supporting circuitry, and demonstrate the capability of eliminating interference in the first stage of the receiver.					
Chip-to-Chip Optical Interconnects (C2OI) (U) Continuing advances in integrated circuit technology are expected to push the clock rates of Complimentary Metal-Oxide Semiconductor (CMOS) chips into the 10 gigahertz (GHz) range over the next four to six 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 is developing optical technology for implementing chip-to-chip interconnects at the board and back plane level. *FY 2009 Accomplishments:* - Developed a chip-scale opto-electronic transceiver circuit based on C2OI technology and demonstrated operation equivalent to 1 Terabit per second (Tbit/s) (consisting of twenty-four bidirectional channels each operating at 20 Gigabits/second (Gb/s)). - Developed a chip-scale opto-electronic transceiver consisting of twelve bidirectional channels each operating at 15 Gb/s that is fully integrated with commercially manufactured circuit boards. *FY 2010 Plans:* - Initiate efforts to complete a full system-scale demonstration of the use of C2OI technology approaches through the optical interconnect of two high performance computer servers using embedded C2OI technology with commercial circuit boards.	3.112	1.025	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete a Technology/Manufacturing Readiness Assessment for C2OI technology with respect to commercial supercomputing and military high-performance embedded computing environments.					
Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) (U) The vision of the Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) program is the development of biological-scale neuromorphic electronic systems for autonomous, unmanned, robotic systems where humans are currently the only viable option. The successful development of this technology will revolutionize warfare by providing intelligent terrestrial, underwater, and airborne systems that remove humans from dangerous environments and remove the limitations associated with today's remote-controlled robotic systems. Applications for neuromorphic electronics include not only robotic systems, but also natural human-machine interfaces and diverse sensory and information integration applications in the defense and civilian sectors. If successful, the program will also reinvigorate the maturing microelectronics industry by enabling a plethora of computer and consumer electronics applications. *FY 2009 Accomplishments:* - Developed a nanometer scale electronic synapse exhibiting the critical communication, processing and learning functions of biological synapses. - Developed microcircuit architecture employing hybrid complementary metal oxide semiconductor (CMOS) and high-density electronic synapses to replicate core functions of lower-level biological neural systems. *FY 2010 Plans:* - Develop a brain-inspired neuromorphic architectural design and specification capability. - Develop software tools to translate neuromorphic designs into electronic implementations using hybrid CMOS and high-density electronic synapse components. - Develop capability to simulate the performance of neuromorphic electronics systems using very large scale computation.	19.530	18.849	19.608	0.000	19.608

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop virtual reality environments intended for training and evaluating electronic neuromorphic systems and their corresponding computer simulations. - Develop standard testing protocols for assessing the performance of large neuromorphic electronic systems. *FY 2011 Base Plans:* - Demonstrate all core microcircuit functions in hybrid CMOS/electronic synapse hardware. - Demonstrate a dynamic neural system simulation of approximately one million neurons that shows plasticity, self-organization, and network stability in response to sensory stimulus and system level reinforcement. - Develop the ability to design electronic neuromorphic systems of 100 billion neurons with mammalian connectivity. - Demonstrate virtual environments with a selectable range of complexity across the cognitive capabilities of small to medium sized mammals. - Specify a chip fabrication process supporting 1 million neurons per square centimeter and ten billion synapses per square centimeter.					
Ultrabeam (U) The goal of the Ultrabeam program is to demonstrate the world's first gamma-ray laser using laboratory equipment. Compact gamma ray lasers can enable the development of new and more effective radiation therapies and radiation diagnostic tools for medical and materials/device inspection applications. This unique X-ray laser technology could also eventually enable the development of compact, laboratory-scale high-brightness coherent sources for 3-Dimensional molecular scale imaging of living cells and debris-free advanced lithography. *FY 2009 Accomplishments:* - Demonstrated excitation of inner shell and nuclear levels in candidate gamma ray gain media.	3.419	1.647	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrated modeled gain of greater than 50 cm^-1 in high atomic-number (Z greater than 70) candidates. - Estimated X-ray source scaling limits and source requirements for candidate gamma ray gain systems. - Demonstrated 50 milli Joule (mJ), 0.03 femtosecond (fs) X-ray laser output pulse. *FY 2010 Plans:* - Demonstrate gamma-ray amplification with a gain of greater than 100 cm^-1.					
Radio Isotope Micro-Power Sources (RIMS) (U) The Radio Isotope Micro-Power Sources (RIMS) effort will develop the technologies and system concepts required to safely produce 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 MicroElectroMechanical Systems (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, radio frequency identification tags, and other applications requiring relatively low (up to tens of milliwatts) average power. *FY 2009 Accomplishments:* - Demonstrated advanced dielectrics with high stability suitable for solid-state capture devices. *FY 2010 Plans:* - Optimize source and dielectric for integrated power system designs.	1.229	1.140	0.000	0.000	0.000
Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM)	3.000	2.500	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The goal of the Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM) program is to develop and demonstrate new technologies for Group II-VI (e.g., Cadmium Selenide (CdSe)) and III-V (e.g., Gallium Nitride (GaN)) materials and device manufacturing, enabling imaging and emissive device fabrication at one percent to ten percent of current costs. This advance will dramatically expand the application space of such devices, by providing lower cost per large area infrared (IR) imaging systems, non-planar devices and systems, and thin film and flexible devices and systems. This program will demonstrate IR detectors and imagers, Light Emitting Diodes (LED), and solid-state lasers fabricated via new methods, and include a rapid demonstration of at least five times reduction in yielded device cost. *FY 2009 Accomplishments:* - Developed and demonstrated techniques for layer doping of heterostructure materials. - Grew monocrystaline p-type GaN material with biased target based deposition based manufacturing process. - Demonstrated lift-off and substrate recycling. - Identified process optimization paths for improved material characteristics and expanded potential suite of low-cost devices that can be fabricated. *FY 2010 Plans:* - Demonstrate fabrication technologies that support the fabrication of affordable emissive microdisplays. - Extend novel fabrication techniques to demonstrate initial device concepts. - Demonstrate scalability of novel manufacturing techniques.					
Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER) (U) The objective of the Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER) program is to develop chip-scale dense waveguide	1.000	2.800	6.800	0.000	6.800

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
modular technology to achieve true embedded phase array control for beams equivalent to 10W average power, less than 0.1 degree instantaneous field of view (IFOV), greater than 45 degree total field of view (TFOV), and frame rates of greater than 100 Hertz (Hz) in packages that are “chip-scale.” Such performance will represent a three order of magnitude increase in speed, while also achieving a greater than two orders of magnitude reduction in size. Additionally, the integrated phase control will provide the unprecedented ability to rapidly change the number of simultaneous beams, beam profile, and power-per-beam, thus opening a whole new direction in operational capability. Key technical challenges include the ability to achieve the needed facet density (facet pitch should be on the order of a wavelength or two), control the relative phase across all facets equivalent to 9-bits, and efficiently couple and distribute coherent light to facets from a master laser oscillator with an integrated waveguide structure. Related projects and studies have pointed to the significant system-level pay-offs of the new proposed technology. *FY 2009 Accomplishments:* - Began research on transmit and receive photonic phased array technologies. *FY 2010 Plans:* - Evaluate transmit and receive photonic phased array technologies. *FY 2011 Base Plans:* - Demonstrate chip scale beam-forming capability in laboratory. - Demonstrate integrated photonic phased array transceiver concept.					
Analog-to-Information (A-to-I) (U) The Analog-to-Information (A-to-I) program will leverage recent dramatic breakthroughs in digitization techniques and hardware to enable accurate extraction of useful information from broadband environments crowded with diverse signals and interference spread over a large dynamic range. The program will satisfy DoD’s requirements for radio frequency (RF) applications of the present	5.970	9.910	7.120	0.000	7.120

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and the future. Additionally, by extracting signals of interest during the measurement phase, A-to-I based approaches reduce the bandwidth and resolution requirements of analog-to-digital converters, and simultaneously reduce the data glut that impacts downstream processing of digitized signals. *FY 2009 Accomplishments:* - Systematically exploited practical hardware and software implementations of the most promising approaches from study phase: compressive sampling, variable projective unfolding, and nonlinear affine encoders. *FY 2010 Plans:* - Prototype critical hardware components of the design in order to avoid risk early; models based on performance measurements of these components will be incorporated into the simulation of the overall receiver. *FY 2011 Base Plans:* - Develop and demonstrate brassboard A-to-I receivers and demonstrate against realistic and challenging RF environments in simulator, chamber, and/or live field tests.					
MultiScale Optical Sensor Array Imaging (MOSAIC)* *Formerly Computational Imaging (CI). (U) The Multiscale Optical Sensor Array Imaging (MOSAIC) program will develop new imaging constructs that exploit the full information content (intensity, phase, and frequency) at the detection plan to perform real-time image processing in the analog domain. This will be combined with advanced digital image processing algorithms to leverage the unique image plane information for more rapid image analysis and target identification. This will lead to revolutionary advances in the detection, precision identification, tracking and destruction of elusive targets.	1.000	6.000	11.340	0.000	11.340

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Began the prototype development of a practical 3-Dimensional (3-D) spatial imager that captures intensity, frequency, and phase information of naturally illuminated scenery. *FY 2010 Plans:* - Demonstrate prototype 3-D spatial imager with associated spatial processing algorithms. *FY 2011 Base Plans:* - Demonstrate real-time tracking and automated-target recognition with improved robustness compared to conventional passive imaging systems.					
Electric Field Detector (E-FED) (U) The goal of the Electric Field Detector (E-FED) program is to develop a small room temperature electric field sensor/sensor array based on new optical electric field sensor architectures. Electric fields are ubiquitous in the warfighter environment. It is expected that these compact sensor arrays will be useful for the monitoring of brain activity and muscle action without the need to apply electrodes directly in or on the surface of the skin. The arrays would also be useful for the remote sensing of electronics, motors, and communications devices enabling the sensing of these devices at greater distances with a more unobtrusive and portable system. *FY 2009 Accomplishments:* - Explored techniques to control the effect of noise sources on the sensor function. *FY 2010 Plans:* - Demonstrate sensors sensitive to an alternating electric field of 1 million volts (mV)/mHz^1/2 from 1-10,000 Hertz (Hz). The sensor would have a dynamic range of 100 and a footprint size of no greater than 25 mm^2.	1.000	3.807	8.795	0.000	8.795

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Develop techniques to increase the frequency range, dynamic range and sensitivity of the electric field sensors while reducing their size. - Explore manufacturing techniques in order to produce electric field sensor arrays with high reproducibility.					
Integrated Photonic Delays (iPhoD) (U) The Integrated Photonic Delays (iPhoD) program will enable unprecedented integrated optical delay performance and complexity, thereby furthering the technological precision of our military. The iPhoD program will build the framework of a scalable integrated photonic platform technology that provides for the handling and manipulation of photons with throughput efficiency and precision approaching that of electrons within electronic integrated circuits. *FY 2009 Accomplishments:* - Demonstrated a minimum, on-chip, optical time delay of 100 nanoseconds (ns). *FY 2010 Plans:* - Refine waveguide materials, fabrication and coupling approaches. - Demonstrate a precise and low loss fiber input/output coupling technology. *FY 2011 Base Plans:* - Scale up and improve waveguide materials, processes, and devices to the performance levels needed for successful demonstration of an array processor. - Fabricate an array processor with at least 500 ns of on-chip optical delay for the longest path.	2.452	5.809	10.539	0.000	10.539
Quantum Sensors (U) The Quantum Sensors program exploits non-classical effects to improve the resolution and range of military sensors. The objective of the program is to enhance sensitivity, resolution, and effectiveness	3.612	5.089	9.639	0.000	9.639

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
of electromagnetic sensors beyond what is classically possible. In the initial effort, the types of sensors that propagate entangled light out to and back from a target were proven to be ineffective when realistic scattering and absorption occur between the source and the target. Sensors that propagate classical light to the target but use non-classical effects only in the receiver were shown to provide qualitative advantages over their classical counterparts. These include compensation for soft aperture losses using squeezed vacuum injection and compensation for detectors' quantum inefficiency using noiseless amplification. A new approach, quantum illumination, retains some entangled light in the receiver and transmits the remainder to the target promising substantial enhancements over detection and imaging of targets in the presence of high levels of noise and loss. *FY 2009 Accomplishments:* - Began engineering of a Type II sensor that: -- Demonstrated and quantified compensation of soft aperture loss by squeezed vacuum injection in homodyne laser radar in a range environment. -- Demonstrated noiseless amplification for sensors with low quantum efficiency. *FY 2010 Plans:* - Complete design and build laser radar with combined squeeze vacuum injection and noiseless amplification. *FY 2011 Base Plans:* - Complete system integration and field testing. - Transition technology to military services.					
Parametric Optical Processes and Systems (POPS) (U) The Parametric Optical Processes and Systems (POPS) program will demonstrate all optical signal processing based on Four Wave Mixing (FWM) in optical fibers and using silicon waveguides to achieve data rates of 100 Gigabits per second (Gb/s) to 1 Terabit per second (Tb/s). This program will develop	1.834	3.577	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
components such as wavelength-shifting wideband amplifiers, tunable optical delays, and parametric sampling for this application. These components will be used in higher level sub-systems such as serializers, de-serializers, and wavelength grooming devices at high data rates of 100 Gb/s - 1Tb/s. These demonstrations of functionality will also include quantitative bit error rate measurements. POPS components and subsystems will enable optical communications at data rates ten times higher than currently possible with conventional approaches. POPS technology will allow all optical manipulation of high rate data streams with a precision and flexibility not currently possible. *FY 2009 Accomplishments:* - Demonstrated serializer component with data rate of 320 Gb/s. - Demonstrated deserializer component with granularity of 40 Gb/s. - Demonstrated 500 ns continuous parametric delay technology. *FY 2010 Plans:* - Demonstrate enhanced serializer component with data rate of 640 Gb/s. - Demonstrate enhanced deserializer component with granularity of 10 Gb/s. - Demonstrate 3000 ns continuous parametric delay technology.					
Spin Torque Transfer-Random Access Memory (STT-RAM) (U) The Spin Torque Transfer-Random Access Memory (STT-RAM) program will develop materials and processes to fully exploit the spin-torque transfer (STT) phenomenon for creating “universal” memory elements. This program will develop the core technology for exploiting spin-torque transfer and related phenomena for producing large-scale memories. Compatibility and stability with expected mainstream processes for semiconductor electronics and patterned media is an important attribute that should enable significant leverage for these new technologies in delivering early demonstrations and in gaining wider acceptance.	2.978	5.277	7.565	0.000	7.565

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed fabrication techniques and device architectures that exploit various materials. *FY 2010 Plans:* - Develop magnetic materials and architectures that allow for fast low power switching in a STT architecture. - Demonstrate fast low power STT memory cell that has size and endurance similar to current non-volatile electronic memories. *FY 2011 Base Plans:* - Develop improved magnetic materials that allow for faster and lower power switching in the STT architecture. - Develop processes and circuit designs to manufacture operational memory arrays in high yield.					
Self-HEALing mixed-signal Integrated Circuits (HEALICs) (U) The goal of the Self-HEALing mixed-signal Integrated Circuits (HEALICs) program is to develop technologies to autonomously maximize the number of fully operational mixed-signal systems-on-a-chip (SoC) per wafer that meet all performance goals in the presence of extreme process technology variations, environmental conditions, and aging. This program is an outgrowth of mixed signal development in the Design Tools for 3-Dimensional Integrated Circuit program. Virtually all DoD systems employ mixed-signal circuits for functions such as communications, radar, navigation, sensing, high-speed image and video processing. A self-healing integrated circuit is defined as a design that is able to sense undesired circuit/system behaviors and correct them automatically. The motivation for this program came from findings under the TRUST program that, as semiconductor process technologies are being scaled to even smaller transistor dimensions, there is an exponential increase in intra-wafer and inter-die process variations, which have a direct impact on realized circuit performance manifested as significantly reduced yields of fabricated fully operational SoC. The core goal of the HEALICs program is to regain this lost performance. Additionally, the technology developed under this	11.500	15.310	16.810	0.000	16.810

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
program is expected to address environmental variations and aging as well. Consequently, the long-term reliability of DoD electronic systems is expected to be significantly enhanced. *FY 2009 Accomplishments:* - Developed self-healing control for individual sub-blocks within a larger mixed-signal core. - Integrated sub-blocks into larger mixed-signal cores (anticipated transistor counts in the 1k-10k range). - Developed global self-healing control algorithms. *FY 2010 Plans:* - Continue development of self-healing mixed-signal cores. - Demonstrate increase in performance yield of mixed-signal cores to greater than seventy-five percent with minimal power and die area overhead. *FY 2011 Base Plans:* - Integration of previously demonstrated mixed-signal cores into a full microsystems/SoC. - Develop global self-healing control at the microsystem/SoC level.					
COmpact Power Processing Electronics Research (COPPER) (U) The COmpact Power Processing Electronics Research (COPPER) program will address the fundamental limitations of power conversion by enabling a new technology and approach that exploits advances in basic power devices that can operate at very high frequencies with low losses. A key benefit of these new devices is that they can be integrated into very compact circuits and assemblies that will provide dramatic advances to the power bus of a platform. Specifically, this program will develop the technology to enable DC to DC power conversion for military applications at the scale of an integrated circuit so it can be embedded within the electronics subsystem and a new distributed power architecture can be realized. The focus of this program is on attaining 100MHz internal operation	0.000	0.000	7.000	0.000	7.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
frequencies of power circuits since the size of the passive elements (inductors and capacitors) in a power converter scales as the fourth power of the internal operating frequency. *FY 2011 Base Plans:* - Develop design and initial fabrication of critical sub-circuits and perform measurements in laboratory. - Develop theoretical design and analyses for understanding of the high-frequency trade-off space of relevant circuit designs and topologies. - Develop design of high frequency converter prototype. - Develop new fabrication techniques for incorporating high frequency transistors and devices with capacitors and inductors to realize the advanced converter. - Document measurements of converter efficiency and losses.					
Efficient Linearized All-Silicon Transmitter ICs (ELASTx)* *Formerly Millimeter-wave All-Silicon Transmitters (MASTR). (U) The goal of the Efficient Linearized All-Silicon Transmitter ICs (ELASTx) program is the development of revolutionary high-power/high-efficiency/high-linearity single-chip millimeter (mm)-wave transmitter integrated circuits (ICs) in leading edge silicon technologies. The high levels of integration possible in silicon technologies enable on-chip linearization, complex waveform synthesis, and digital calibration and correction. Military applications include ultra-miniaturized transceivers for satellite communications-on-the-move, collision avoidance radars for micro-/nano-air vehicles, and ultra-miniature seekers for self-guided munitions. The technology developed under this program could also be leveraged to improve the performance of high-power amplifiers based-on other non-silicon technologies through heterogeneous integration strategies. Significant technical obstacles to be overcome include the development of efficient circuits for increasing achievable output power of silicon devices (e.g., effective breakdown voltage enhancement, power combining) at mm-waves; scaling	0.000	5.804	11.583	0.000	11.583

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
high-efficiency amplifier classes to the mm-wave regime; robust mixed-signal isolation strategies; and thermal management considerations. *FY 2010 Plans:* - Demonstrate high-power (Watt-level), high power-added-efficiency (greater than or equal to fifty percent) power amplifier (PA) circuits at Q-band frequencies. - Develop design techniques for on-chip linearization of high-efficiency silicon PAs. *FY 2011 Base Plans:* - Demonstrate high-power (Watt-range) high power-added-efficiency (greater than or equal to fifty percent) PA circuits at W-band frequencies. - Demonstrate a Q-Band linearized transmitter with Watt-level output power, fifty percent range power added efficiency, and extremely high linearity for complex communications signals.					
Remoted Analog-to-Digital Converter with De-serialization and Reconstruction (RADER)	1.785	4.500	10.400	0.000	10.400
(U) The objective of the Remoted Analog-to-Digital Converter with De-serialization and Reconstruction (RADER) program is to develop a novel analog to digital converter (ADC) front-end that acts as a performance multiplier for conventional ADCs. This program is an outgrowth of the Analog-to-Information research. The military's need to operate in dense signal environments, performing friendly communications and detecting low-power adversarial signals concurrently, requires ADCs with unparalleled resolution and wide instantaneous bandwidth (IBW). Commercial systems available today are capable of achieving high resolution, or wide bandwidth, but not both at the same time. To meet the military's need, the RADER program will develop a system that uses many commercial-off-the-shelf (COTS) ADCs in conjunction with a novel de-serializer front-end architecture to meet both the resolution and bandwidth requirements simultaneously. ADC systems enabled by RADER technology will be capable of operating in continuous time over a 10 GHz input IBW with a signal-to-noise resolution of 10 effective number of bits, an 8 bit improvement over COTS ADCs. These improvements will be accomplished using a remotable architecture in which most of the ADC's size, weight and power will					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
be remotely located from the signal environment—where space and supply power are more readily available (such as below a ship's deck) and the system itself will not alter the platform's center of gravity or create deleterious electronic noise for other systems *FY 2009 Accomplishments:* - Initiated system development of bandwidth measurements. *FY 2010 Plans:* - Develop Phase I RADER architecture. *FY 2011 Base Plans:* - Demonstrate 8 effective number of bits (ENOB) system operating at 10 GHz IBW. - Demonstrate 57 dB spurious free dynamic range (SFDR).					
Advanced CAD (U) The Advanced Computer-Aided Design (CAD) Program will radically overhaul the way circuit and system design is carried out, and in the process make the most advanced technologies under development for DoD use accessible to a far broader base of talented designers than at present. The principle aim of this effort is to develop a unifying framework for design and simulation of electronic systems that intelligently and seamlessly harmonizes the multiple interacting phenomena that must be dealt with in state-of-the-art system development. For example, it has become essential to consider, across length-scales from nanometers to meters, the actions and interactions of electronic, electromagnetic, mechanical, thermal, quantum, and fabrication process effects. Also, it is critical to co-optimize and co-design system functions across all of these domains – currently not possible. In the past, clunky individual software modules would separately estimate system behavior in one domain at a time, then pass the estimates to subsequent domain-specific codes. This program will result in a unified and modern code base for this purpose, importantly incorporating device and technology models reaching well beyond the state-of-the-art into cutting edge technologies. The program will	0.000	0.000	8.689	0.000	8.689

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
enable designers to explore all possible options. Another key goal of this effort is to integrate cognitive functions for immediate design assistance and real-time estimation to provide intuition-building feedback to the designer mimicking the effect of turning a knob and seeing what happens to a circuit on a bench. The overall outcome of this effort is expected to be a dramatic lowering of the barrier to entry for designers to access the best technologies, as well as a huge force multiplier in terms of designer productivity. *FY 2011 Base Plans:* - Demonstrate through simulations that co-design of processor algorithm achieves greater processing efficiency. - Develop tool set for design methodology for optimized co-design, demonstrating logical abstractions for hardware functional blocks and complex non-linear interactions between different functional blocks of a microsystem. - Investigate designs to demonstrate feasibility of two-times reduction in communication power for high density wafer-scale communication.					
Advanced Imaging (U) The ability to see farther with higher clarity and through darkness and/or obscurants is vital to nearly all military operations. At the same time, there is immense pressure to reduce the size, weight, and power (SWAP) requirements of advanced imaging systems. In the past, the main driver for this was the need for dismounted soldiers to carry the best available imaging tools – often a matter of life and death. With the advent of smaller and smaller UAVs, which can provide a huge advantage to our troops, the pressure to miniaturize and reduce power is even more intense. This program responds to that need by simultaneously pushing the envelope of imager performance through new detector devices and also dramatically reducing SWAP for UAV and head-worn applications. Technology approaches will include removing the power- and space-hungry cooling requirement of previous generation imagers,	0.000	0.000	7.844	0.000	7.844

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
pushing to increase resolution and sensitivity through new photon detectors such as nanoantenna-coupled detectors. *FY 2011 Base Plans:* - Investigate novel material and device designs that enable uncooled operation at infrared wavelengths. - Design of impedance-matched nano-structured antennas to couple long wavelength radiation to detector pixels in focal plan arrays with thousands of elements.					
Compact Mid-Ultraviolet Technology (U) The goal of the Compact Mid-Ultraviolet Technology program is to develop compact high-brightness Middle Ultraviolet source and detector technologies based on wide band gap diode structures. This program will address a critical technology shortfall preventing mid-UV capability in portable chem-bio defense systems for aerosol detection (enhanced capability for small particulates), chem-bio identification (Raman scattering and spectroscopy), and chemical decontamination/water purification applications. The technologies will also address solar-blind detectors for missile plume identification. *FY 2010 Plans:* - Develop large non-absorbing (UV transparent) low-defect-density substrate materials on which to grow devices. - Develop high-quality, highly-strained epitaxy to confine carriers and provide the required energy band offsets. - Initiate highly efficient electric injection of carriers to improve quantum efficiency. - Demonstrate low-resistance non-absorbing contacts. *FY 2011 Base Plans:* - Demonstrate diode operation at proposed mid-UV wavelength.	0.000	8.000	15.000	0.000	15.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Create high-quality aluminum nitride (AlN) substrates to enable development of optimized devices. - Design and develop epitaxial structures for mid-UV light-emitting diode (LED) sources and detectors.					
Enabling Future Energy Concepts Through Microsystem Technologies (U) The DoD mission demands continuous pursuit of the most advanced portable, reliable and dense energy systems. A large number of critical systems are limited in performance and/or mission duration by the amount of electrical energy available at the point-of-use. This program seeks to create breakthrough advances in power storage, management and delivery, all enabled via the application of microsystems technologies. A core component of this effort will be the development of new architectures, reversible electrode structures, materials, and chemistries for the development of rechargeable, high energy density batteries that match or exceed energy density of hydrocarbon fuels (e.g. gasoline, JP8, etc.), requiring the energy density to increase over ten-fold compared to current lithium ion batteries. An equally important aspect of this program is the development of novel electromagnetic switching power converters to optimize the efficiency of energy use at the micro scale. In order to achieve this, both materials and circuits are necessary. Advanced micromagnetic materials and fabrication techniques will be developed to achieve greatly improved performance (i.e., > 100x higher magnetic permeability, > 20x higher magnetic-energy product, 140% higher magnetic saturation) in a reliable microsystem-compatible manner. With the resulting tiny inductors that can be directly merged with integrated circuits, it will be possible not only to allow every battery to optimize its own performance, but to allow integrated circuits to locally regulate their own energy supplies. This profound change away from centralized power systems will yield dramatic size, weight and efficiency improvements across scales from individual integrated circuits through entire phased-array radar and other large electronic systems. All of this translates into lower energy requirements, smaller logistics tails, reduced heat dissipation, and increased system reliability. *FY 2011 Base Plans:* - Investigate chemistry and materials to enable rechargeable high energy density batteries.	0.000	0.000	8.845	0.000	8.845

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate integration path for light sources and spherical atomic shells in arrays on a single wafer.					
Transformational Antenna Technologies (U) The Transformational Antenna Technology program goal is to develop and demonstrate new and innovative antenna design concepts that have the potential to fundamentally change the way that the Department of Defense (DoD) exploits the electromagnetic spectrum. The focus of the effort is to develop antennas that are physically or electrically small to support a variety of warfighter needs, such as applications including integration on small and micro UAVs, low observable platforms, soldier radios and manpacks. This program is attempting to reduce antenna size, provide additional sensitivity, and increase the frequency band over which small antennas operate. These techniques will give new levels of flexibility to our radio technology, enabling not only communications but intelligence gathering, jamming, and information operations on the same radio equipment, and implementation of new capabilities on smaller platforms such as UAVs. The antennas that will be developed will be smaller, and cover a wider range of frequency bands. The technologies and systems developed under this program support all Services. *FY 2011 Base Plans:* - Develop and model realistic electrically small antenna designs at a wide range of frequencies. - Develop methods of implementing transmit non-Foster matching circuits over wide bandwidths. - Develop integrated circuit designs that can be used to create specialized circuits for a wide range of impedance matching problems. - Develop methods to perform antenna beam management using only a single antenna port on a radio. - Develop methods to adjust antenna topology, resonant structure, and polarity. - Develop new scalable design techniques that support conformal implementation on surfaces of wings and fuselage of a variety of aircraft designs.	0.000	0.000	8.000	0.000	8.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Apply tunable superconducting filter development to specific radio receiver requirements for the Services.					
Terahertz (THz) Photonics (U) The Terahertz (THz) Photonics program will enable semiconductor continuous-wave laser sources that are THz frequency sources operating at room-temperature. Approaches to such sources include quantum cascade lasers and quantum dot lasers. Although the field of THz photonics has grown considerably, the physical path to an efficient continuous wave laser source at room temperature has eluded researchers prior to this program. The program will demonstrate designs that enable laser sources at these frequencies by mitigating the degradation of population inversion at room temperature. The program will invent an alternative laser active-region design, or more radically, use a new material system such as the gallium arsenide-based system to maintain the population inversion for lasing at room temperature. Highly efficient laser sources for portable systems such as infra-red counter-measures and active imagers will be enabled by this program. *FY 2011 Base Plans:* - Investigate laser designs for room temperature emission at THz frequencies.	0.000	0.000	6.745	0.000	6.745
Near-Junction Transports (NJT) (U) The Near-Junction Transport program will consist of fundamental research into heat conduction through materials layers near a high-power device junction. This program will develop and verify accurate quantitative models for heat generation and transport in and near device junctions to include development of novel high spatial and temporal resolution metrology techniques, fabrication of device-compatible materials and interfaces expected to offer unique thermal characteristics resulting in the development of models, tools, and materials for near-junction thermal management in a broad class of electronic device materials. The second stage will concentrate on development of specific materials to enhance the local heat-spreading in the region of the semiconductor chip. Industry leaders with the expertise in developing high-power semiconductor devices will be expected to demonstrate	0.750	2.750	10.150	0.000	10.150

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
significantly enhanced heat density and the use of enhanced heat spreading technologies within an existing fabrication process. Additionally, the program will address developing novel device-scale structures to enable highly conductive thermal paths to remove unwanted heat from electronic devices. The impressive improvements obtained through miniaturization and integration in electronics have led to a thermal bottleneck where dense logic circuits, mixed-signal analog and digital circuits, and RF electronics are all limited by energy dissipation in small volumes. Realizing the material benefits of gallium nitride and other wide band gap materials for power applications will not be possible unless the thermal conductance at or near an electronic junction is significantly improved. Power densities that approach material-limited performance for high powers may be enabled by integrating high conductivity materials, such as diamond films or nanostructures such as carbon nanotubes or graphene-related structures that control the phonon behavior to increase thermal conductance. This program is a companion program to the consolidated Thermal Management Technologies program in PE 0603739E, Project MT-12. *FY 2009 Accomplishments:* - Developed and verified accurate quantitative models for heat generation and transport in near device junctions. - Developed novel, high, spatial and temporal resolution metrology techniques. *FY 2010 Plans:* - Fabricate device-compatible materials and interfaces expected to offer unique thermal characteristics. - Develop models, tools, and materials for near-junction thermal management in a broad class of electronic device materials. *FY 2011 Base Plans:* - Develop specific materials to enhance the local heat-spreading in the region. - Develop high-power semiconductor devices.					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate the use of enhanced heat spreading technologies within an existing fabrication process. - Demonstrate significantly enhanced heat density utilizing high-power semiconductor devices. - Identify nanostructured material designs for revolutionary thermal pathways compatible with electronic devices. - Explore the potential improvement possible by the use of phonon engineering.					
Non-Silicon Electronics The goal of the Non-Silicon Electronics program is to develop a new generation of vacuum electronic devices in which nano-scale structures are integrated with transistors to overcome traditional limitations in reliability and performance. While the commercial electronics world is almost totally dominated by silicon transistors, military systems can benefit enormously from the additional performance enabled by the use of alternate materials. These include phosphides (e.g., InP), antimonides (InSb), and nitrides (GaN). For example, the ability of GaN to achieve very high frequency operation while maintaining low on-state resistance offers an opportunity to achieve compact, even device-scale DC to DC power conversion systems. Such power conversion systems are virtually omnipresent, and by scaling their size by 10X or more while maintaining high efficiency would potentially lead to new capabilities such as chip-scale power converters. *FY 2011 Base Plans:* - Investigate designs for integrating vacuum electronic nano-structures with semiconductor-based transistors on the same wafer in order to demonstrate high efficiency, high power frequency sources. - Demonstrate RF and power electronics circuits using non-silicon transistor electronics.	0.000	0.000	7.725	0.000	7.725
Revolutionary Mixed-Signal Electronics (U) Since the earliest days of electronic circuits, there has been a synergistic relationship between the electronic device technology of the day and the circuit design ideas that combined them into systems of steadily increasing complexity and capability. While commercial industry is strongly	0.000	0.000	7.845	0.000	7.845

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
driving the scaling and performance increase of CMOS circuitry, an undesirable side-effect of the "Moore's Law" scaling is the collapsing of the dynamic range (signal swing range) of analog circuits which are increasingly forced to coexist with digital circuits (on so-called "mixed-signal" integrated circuits). DoD requirements for electronics pull in exactly the opposite direction, requiring increased dynamic range, increased power density, and increased linearity, among other features. In order to harness commercial technologies and augment them to meet DoD needs, a combined approach will be taken, coupling evolving semiconductor device capabilities with innovative new circuit topologies. For example, new Gallium Nitride and vacuum devices will be harnessed to push to the limits of speed (terahertz), dynamic range, and power densities for applications such as extending the reach of radars and jam-proofing communications systems. Design techniques for optimally combining heterogeneous device technologies such as these with mainstream silicon circuits will allow the development of circuits with heretofore impossible performance capabilities. Finally, novel silicon-only design approaches will harness, at the lowest possible cost, secure commercial CMOS capabilities to trade abundant transistor speed for extended dynamic range, linearity and power efficiencies. Overall, this program seeks to develop entirely new designs and design methodologies to push the envelope of mixed signal performance across the entire spectrum of advanced device types available for DoD applications. *FY 2011 Base Plans:* - Design radio architectures that achieve 400 times reduction in signal recognition energy as compared to state of the art radios.					
Micro Isotope Micro-Power Sources (MIPS) (U) The goal of the Micro Isotope Micro-Power Sources (MIPS) program was to demonstrate safe, affordable micro isotope power sources able to outperform conventional batteries in terms of energy and/or power density, and provide long lasting milliwatt-level power for an array of critical military applications, such as unattended sensors, perimeter defense, detection of weapons of mass destruction, and environmental protection.	2.173	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated radiation hardened Boron Carbon (BC) junctions with >10% efficiency. - Demonstrated thermophotovoltiac conversion system. - Demonstrated thermo electric conversion system.					
Visible InGan Injection Lasers (VIGIL) (U) The objective of the Visible InGan Injection Lasers (VIGIL) program was to demonstrate injection lasers emitting in the green wavelength. The specific program goal was to demonstrate continuous wave green injection lasers operating at room temperature with a power output up to 1 watt, wall plug efficiency of thirty percent, and laser output stability over time periods of at least 1000 hours. VIGIL lasers will enable applications requiring a close match between the wavelength of the light source and the peak response wavelength of the human eye. Another class of applications will take advantage of the minimum absorption of seawater in the blue-green spectral region. Other applications include miniaturized displays and pumps for generation of high-frequency mode-locked combs. *FY 2009 Accomplishments:* - Grew Indium Gallium NItride (InGaN) quantum wells with low defect densities (less than 10,000 defects per square cm) on both polar and non-polar Gallium Nitride substrates.	5.832	0.000	0.000	0.000	0.000
Chip Scale Atomic Clock (CSAC) (U) The Chip Scale Atomic Clock (CSAC) demonstrated 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 Global Positioning System (GPS) signal locking.	1.371	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated design and fabrication innovation for atomic-confinement cell and for gigahertz (GHz) resonators suitable for phase locking or direct coupling with atomic confinement cell.					
Photonic Analog Signal Processing Engines with Reconfigurability (PhASER) (U) The goal of the Photonic Analog Signal Processing Engines with Reconfigurability (PhASER) program was the creation of new Photonic Integrated Circuit (PIC) elements, and associated programmable filter array concepts that enabled high-throughput, low-power signal processors. The focus was on the development of novel "Unit Cells," which may be used as building blocks to synthesize arbitrarily complex filters within a PIC platform for ultra-high bandwidth signal processing applications. *FY 2009 Accomplishments:* - Demonstrated an experimental Unit Cell concept. - Determined how the Unit Cell, when arrayed within a high-density PIC performed. - Developed a filter synthesis tool to demonstrate how Unit Cells enabled generalized high-order filters. - Determined how unit cells were programmed and tested at the chip-level to ensure high yield.	3.995	0.000	0.000	0.000	0.000
Linear Photonic RF Front End Technology (PHOR-FRONT) (U) The goal of the Linear Photonic RF Front End Technology (PHOR-FRONT) program was 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 Megahertz (MHz) – 20 Gigahertz (GHz) range. These field programmable, real-time adaptive photonic interface modules will find application in high dynamic range communications, radar and Electronic Warfare antenna applications.	2.875	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed compact linear photonic receivers with improved sensitivity and dynamic range.					
Optical Arbitrary Waveform Generation (OAWG) (U) The ultimate vision for the Optical Arbitrary Waveform Generator (OAWG) program was to demonstrate a compact, robust, practical, stable octave-spanning optical oscillator, integrated with an encoder/decoder capable of addressing individual frequency components with an update rate equal to 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-wide band optical communications. *FY 2009 Accomplishments:* - Demonstrated production of pseudo-random pulse sequence with 5 GHz instantaneous bandwidth and measurement of 24 dB gain in matched filter output. - Investigated insertion of OAWG technology into high performance radar and laser radar systems. - Constructed system to produce 1,000 GHz positive linear chirp with less than five percent least-squared deviation from mathematical ideal waveform and built single-pulse waveform measurement instrumentation.	4.284	0.000	0.000	0.000	0.000
Adaptive Focal Plane Arrays (AFPA) (U) The goal of the Adaptive Focal Plane Arrays (AFPA) program was to demonstrate high-performance focal plane arrays that are widely tunable across the entire infrared (IR) spectrum (including the short-, middle- and long-wave IR bands), thus enabling "hyperspectral imaging on a chip." This program also enabled 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	1.275	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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). *FY 2009 Accomplishments:* - Demonstrated AFPA prototype field using a large format array.					
Accomplishments/Planned Programs Subtotals	179.839	177.402	286.936	0.000	286.936

	FY 2009	FY 2010
Congressional Add: 3-D Technology for Advance Sensor Systems *FY 2009 Accomplishments:* - Continued 3-D device development. *FY 2010 Plans:* - Continue 3-D device development.	1.440	2.000
Congressional Add: Secure Media and ID Card Development *FY 2009 Accomplishments:* - Initiated ID card development.	0.240	0.000
Congressional Adds Subtotals	1.680	2.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.