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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	163.386	199.504	205.912						Continuing	Continuing
MT-07: CENTERS OF EXCELLENCE	4.000	7.000	0.000						Continuing	Continuing
MT-12: MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY	34.975	64.015	77.963						Continuing	Continuing
MT-15: MIXED TECHNOLOGY INTEGRATION	124.411	128.489	127.949						Continuing	Continuing

A. Mission Description and Budget Item Justification

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

(U) The MicroElectroMechanical Systems (MEMS) and Integrated Microsystems Technology project is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems to address issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. The MEMS project has three principal objectives: the realization of advanced devices and systems concepts, the development and insertion of MEMS into DoD systems, and the creation of support and access technologies to catalyze a MEMS technology infrastructure.

(U) The goal of the Mixed Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems. These ‘wristwatch size’, low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. The chip assembly and packaging processes currently in

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use produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form batch-fabricated, mixed technology microsystems ‘on-a-single-chip’ or an integrated and interconnected ‘stack-of-chips’. The ability to integrate mixed technologies onto a single substrate will increase performance and reliability, while driving down size, weight, volume and cost.

(U) The Centers of Excellence project provided funding to finance the demonstration, training and deployment of advanced manufacturing technology at Marshall University and the MilTech Extension program.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	202.942	201.146	198.712	
Current BES/President's Budget	163.386	199.504	205.912	
Total Adjustments	-39.556	-1.642	7.200	
Congressional Program Reductions	0.000	-15.442		
Congressional Rescissions	-10.500	0.000		
Total Congressional Increases	0.000	13.800		
Total Reprogrammings	-23.500	0.000		
SBIR/STTR Transfer	-5.556	0.000		
TotalOtherAdjustments			7.200	

Congressional Increase Details ($ in Millions)

	FY 2008	FY 2009
Project: MT-07, **Institute of Advanced Flexible Manufacturing Systems**	0.000	7.000
Project: MT-15, **Center for Autonomous Solar Power Large Area**	0.000	4.000
Project: MT-15, **Hybrid Power Generation System**	0.000	1.200
Project: MT-15, **Ultra Low Power Electronics for Special Purpose Computers**	0.000	1.600

Change Summary Explanation

FY 2008

Decrease reflects Section 8042 rescission, the AFRICOM reprogramming and the SBIR/STTR transfer.

FY 2009

Decrease reflects the reductions for Section 8101 Economic Assumptions and new starts offset by congressional increases as identified above.

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FY 2010
Increase reflects minor program repricing.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-07: CENTERS OF EXCELLENCE	4.000	7.000	0.000						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Byrd Institute provides both a teaching facility and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training emphasizes technologies to significantly reduce unit production and life cycle costs and to improve product quality.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Advanced Flexible Manufacturing *FY 2008 Accomplishments:* - Assessed the Institute for Advanced Flexible Manufacturing's performance and worked toward transitioning from DoD to state/private support. *FY 2009 Plans:* - Continue to assess the Institute for Advanced Flexible Manufacturing's performance and work toward transitioning from DoD to state/private support.	4.000	7.000	0.000	

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-12: MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY	34.975	64.015	77.963						Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Harsh Environment Robust Micromechanical Technology (HERMIT) (U) The Harsh Environment Robust Micromechanical Technology (HERMIT) program is developing micromechanical devices that can operate under harsh conditions (e.g., under large temperature excursions, large power throughputs, high g-forces, corrosive substances) while maintaining unprecedented performance, stability, and lifetime. Micromechanical RF switches are of particular interest,	5.378	4.983	1.322	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
where sizable power throughputs and impacting operation constitute harsh operational environments. Other applications such as vibrating resonator reference tanks, gyroscopes, and accelerometers are also of interest. Among the HERMIT implementation approaches deemed likely to succeed, two are of the most interest: 1) wafer-level encapsulation or packaging strategies based on MicroElectroMechanical systems (MEMS) technology that isolates a micromechanical device from its surroundings while maintaining a desired environment via passive or active control; or 2) material and design engineering strategies that render a micromechanical device impervious to its environment with or without a package (if possible). A key approach in this program that should allow orders of magnitude power savings is to selectively control only the needed micro-scale environment or volume via MEMS-enabled isolation technologies. The success of this program should enable a myriad of strategic capabilities including lower cost, more complex phased array antennas for radar applications; tiny frequency references with long- and short-term stabilities that greatly extend the portability of ultra-secure communications; and micro-scale inertial measurement units with bias stabilities approaching navigation-grade. The HERMIT program is anticipated to transition via industry to phased array antenna, reconfigurable communication front-end, seeker, and steerable aperture programs being developed by the Army, Navy, and Air Force, as well as to inertial navigation systems and Joint Tactical Radio System (JTRS) communications needed by these Services. *FY 2008 Accomplishments:* - Demonstrated essential elements (e.g., thermistors, heaters, getters) needed for low power control of the operating environment surrounding a micromechanical device. *FY 2009 Plans:* - Demonstrate micromechanical devices (e.g., RF switches, vibrating resonators) fully integrated together with environment isolating measures (including circuits, if any) that maintain unprecedented performance, stability, and reliability, even under harsh environments. - Demonstrate high yield MEMS RF switching component technologies that result in test devices that can operate for at least 100 billion switching cycles. Yield goals are to attain a 95% confidence that 99% of tested devices will meet 100 billion cycles. - Implement parallel measurement set-up to increase test throughput.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Initiate efforts for demonstrating the performance of RF switches in relevant radar applications. *FY 2010 Plans:* - Demonstrate hermetic packaging technology for advanced MEMS inertial gyroscopes and accelerometers.				
MEMS Exchange (U) The MEMS Exchange program seeks to provide flexible access to complex MicroElectroMechanical systems (MEMS) fabrication technology in a wide variety of materials and to a broad, multi-disciplinary user base via the MEMS Exchange service. A major goal of the effort is to ensure self-sustained operation of MEMS Exchange after the end of the program by adding several process modules to the existing repertoire and increasing the number of processes run per year to raise revenues to the point of self-sufficiency. Among the future payoffs of this program is the establishment of an accessible infrastructure for low or medium volume production of MEMS-enabled products for DoD applications. The goal of the MEMS Exchange program is to provide MEMS fabrication services to all levels of industry and academia in support of Army, Navy, Air Force, and other DoD requirements without further DARPA sponsorship. *FY 2008 Accomplishments:* - Doubled the number of runs processed per year to achieve a goal rate of 500 runs per year. - Provided a modular merging process that combines modules together with transistor integrated circuits. *FY 2009 Plans:* - Insert MEMS technology into three DoD applications using MEMS Exchange as the fabrication vehicle. *FY 2010 Plans:* - Implement new state-of-the-art technical unit process capabilities to achieve greater effectiveness for creating MEMS devices, including electron-beam lithography, mixed transistor and MEMS process modules, and general purpose MEMS hermetic packaging. - Initiate new quality control efforts to achieve higher reliability in manufacturing.	2.651	2.700	1.876	
Low Power Micro Cryogenic Coolers (MCC)	3.507	1.810	1.480	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Low Power Micro Cryogenic Coolers (MCC) program will attain superior performance in micro-scale devices (e.g. Low Noise Amplifier (LNA's) IR detectors, RF front-ends, superconducting circuits) by cooling selected portions to cryogenic temperatures. The key approach in this program that should allow orders of magnitude power savings is to selectively cool only the needed volume/device via MEMS-enabled isolation technologies. Such an approach will benefit a large number of applications where performance is determined predominately by only a few devices in a system, e.g., communications where the front-end filter and LNA often set the noise figure; and sensors, where the transducer and input transistor in the sense amplifier often set the resolution. MEMS technology will also be instrumental for achieving micro-scale mechanical pumps, valves, heat exchangers, and compressors, all needed to realize a complete cryogenic refrigeration system on a chip. Transition of this technology is anticipated through industry, which will incorporate elements of the technology in current and future weapon system designs. *FY 2008 Accomplishments:* - Demonstrated micro-scale coolers capable of providing the needed cryogenic temperature while still fitting into a miniature size, with sufficient efficiency for low power operation. - Demonstrated heat exchangers, Joule-Thompson plugs, valves, pumps, all needed for cryo-cooler implementation. *FY 2009 Plans:* - Integrate micro cooler components together with sufficiently isolated devices to-be-cooled to yield a single chip system consuming very little power. *FY 2010 Plans:* - Improve MEMS-derived thermal isolation microstructures. - Develop improved thermoelectric materials for integration with existing and future MEMS.				
Microsystem Integrated Navigation Technology (MINT) (U) The Microsystem Integrated Navigation Technology (MINT) program is developing technology for precision inertial navigation coupled with micro navigation aiding sensors. The MINT program will develop	4.230	10.355	4.867	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
universally reconfigurable microsensors (e.g., for magnetic fields, temperature, pressure) with unmatched resolution and sensitivity. These devices will use the latest in MEMS and photonic technologies to harness perturbations in atomic transitions as the sensing and measuring mechanisms for various parameters. Program transition will occur through industrial performers into future DoD platforms. *FY 2008 Accomplishments:* - Developed technology to dramatically reduce bias drifts in Complementary Metal-Oxide Semiconductor (CMOS)-integrated MEMS accelerometers and gyros. - Developed CMOS-MEMS sensors for precision navigation aids such as velocity ranging and zero-velocity updating. *FY 2009 Plans:* - Reduce power and volume requirements. - Develop technologies to harvest power through energy scavenging. *FY 2010 Plans:* - Develop and demonstrate micro-fabrication technologies for creating new classes of MEMS navigation instruments that can be used for achieving high accuracy, GPS free navigation using zero-velocity updating.				
Thermal Ground Plane (TGP) (U) The Thermal Ground Plane (TGP) program is developing high-performance thermal materials and substrates that will enhance the performance of many DoD systems by greatly improving the thermal path of the embedded electronics and Microsystems. The program will focus on the development of thin, large-area, high-thermal conductivity substrates for multi-chip modules (MCM). Innovations in heat pipes (i.e., wicking structures, working fluids, and casing materials) and related approaches exploiting two-phase fluidic cooling are being pursued to exploit the high thermal conduction, extreme reliability, and lack of moving parts or needs for external power, all critical for the intended application. Technology will be inserted through DoD industrial firms into future DoD systems.	6.081	12.597	10.931	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Developed baseline approach for incorporating new wicks, working fluids, and casing materials for application to MCM's. *FY 2009 Plans:* - Design, fabricate and perform experiments on TGP prototypes and complete initial thermal simulations. *FY 2010 Plans:* - Demonstrate the performance benefits of an integrated TGP through refining of wick materials and tuning the composition of the casing. - Demonstrate a full-performance TGP with enhanced thermal conductivity, hermeticity, and lifetime in a scaled-up 20 cm x 10 cm x <1mm sample.				
Integrated Primary Atomic Clock (IMPACT)* *Formerly titled Micro-Beam Clock. (U) The Integrated Primary Atomic Clock (IMPACT) program will extend the accuracy of Chip Scale Atomic Clock (CSAC) by exploiting the precision of nuclear particle transport. The concept of beam clock has been known at least since the 1960's but has not been widely pursued due to the difficulty in containing a large volume of xenon gas. This problem will be addressed by going to the micro-scale. Miniaturization of the conventional beam clocks with major innovations are possible due to microscale implementation – microscale xenon atom source, micromachined permanent magnets, and micromechanical atom flux detectors. This approach will not only improve the stability over existing CSAC but will further reduce the required power. This technology will be transitioned into DoD systems through innovative companies, including performers under the Chip-Scale Atomic Clock program. *FY 2008 Accomplishments:* - Determined permanent magnet laser cutting at microscale. - Determined High B-field gradients at microscale.	2.000	9.970	8.521	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Determine pressure measurement in presence of high magnetic field with MEMS pressure sensors. - Identify retrace drifts and reduce zero aging of atomic frequency. *FY 2010 Plans:* - Initiate technology development efforts for demonstrating a complete physics package for an advanced miniaturizable atomic clock that can interrogate gaseous atoms and does not suffer from light shifts and buffer gas shifts that usually limit the use of hyperfine transition frequencies for applications to clocks.				
Nano-Electro-Mechanical Computers (NEMS) (U) The goal of the Nano-Electro-Mechanical Computers (NEMS) program is to develop nanoscale mechanical switches and gain elements integrated intimately with complementary metal-oxide semiconductor switches. One mechanical switch per transistor will enable the transistor to operate at near zero leakage powers, enabling pico or femtowatt standby operation. The program will also develop mechanical gain elements using physical effects such as giant magnetoresistance, buckling, electromechanical phase transitions, van der Waals forces, and Casimir forces to enable very low-noise, high-frequency amplifiers for low-power, low-noise analog signal processing. Possibilities of using mechanical power supplies and mechanical vibrating clocks could enable electronics that are less susceptible to electromagnetic pulse attacks. Enabling of nanomechanical elements in direct bandgap materials will circumvent problems of gate oxide stability, allowing fast logic with optics functionality. This program will transition into DoD systems via industrial program performers. *FY 2008 Accomplishments:* - Developed mechanical gain elements for analog amplification using effects such as buckling and electromechanical phase changes. *FY 2009 Plans:* - Develop NEMS switches in direct bandgap materials to enable optical functionality with switches.	7.632	7.916	8.338	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Demonstrate NEMS devices and technologies for microcontroller building blocks - adders, counters, memories, that can operate at very high temperatures.				
Information Tethered Microscale Autonomous Rotary Stages (ITMARS)* *Formerly titled NanoCAD. (U) Early MEMS work had demonstrated many ways of realizing rotating micromotors, and in fact had been the source of major popular interest in the field of micromachines. However, the unique capability to precisely rotate micromachined structures in a controllable manner has been under-utilized in MEMS systems. Although the use in micromotors for optical and mechanical switches has been demonstrated, most applications passively use the structures fabricated into the rotary stage. To date there is no technology able to transmit power and signals to these tiny stages from the substrate on which they are rotating. This program will explore ways at pushing the envelope by engineering ways of coupling power and signals to a rotating MEMS stage, and measuring its position with much higher accuracy then possible at the macroscale. With this capability, arrays of rotating 100-1000 micron diameter stages could carry various sensors that can be aimed at any azimuth and inclination, and can be rotated 360 degrees for cancelling angle dependent biases. Examples of sensors that might utilize this capability include microphones, antennas, radiation sensors, etc. Although many of these sensors exist, by adding the rotating stage functionality without increase in sensor/system size, weight, and power, one can really see the benefit of integrating MEMS with traditional sensors. The program will transition via industry performers. *FY 2009 Plans:* - Initiate efforts to implement power and information to microscale rotating stages, for various applications. *FY 2010 Plans:* - Develop prototype applications.	0.000	4.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Reduce bias levels in sensors, increase directivity in directional sensors, and achieve mechanical phased arrays.				
Microtechnologies for Air-Cooled Exchangers (MACE) Heat Sink Enhancement	2.384	5.684	11.813	
Chip-Scale Spectrum Analyzers (CSSA)	0.000	0.000	4.005	

Microtechnologies for Air-Cooled Exchangers (MACE) Heat Sink Enhancement

(U) The Microtechnologies for Air-Cooled Exchangers (MACE) Heat Sink Enhancement program is developing and demonstrating technologies for creating air-cooled heat exchangers that offers significant performance enhancements over conventional heat rejection systems. The technologies developed under this program will allow the DoD to replace expensive cooling technologies such as spray-cooling and refrigeration with much simpler, low cost air-cooled exchangers without penalties in thermal performance. The program will transition via industrial performers.

FY 2008 Accomplishments:
- Created initial simulation models to gain insight to complex thermal phenomena across multiple interfaces and surfaces.

FY 2009 Plans:
- Complete experiments and analyses of technologies and implementation approaches to enhance the performance and efficiencies of air-cooled exchangers.
- Construct preliminary models detailing scaling and embodying new physics of complex flows.

FY 2010 Plans:
- Fabricate and test a ‘single-fin’ heat sink device.
- Scale up prototype air-cooled exchangers to a large, full-format heat sink.

Chip-Scale Spectrum Analyzers (CSSA)

(U) The Chip-Scale Spectrum Analyzers (CSSA) program will use microresonators to accept very narrow channels of the radio spectrum while rejecting all others. The microresonator is designed to facilitate subsequent digitizing of the analog signal. A successful CSSA program would make possible a universal communications receiver that would be able to reconfigure and operate under any communication

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
standard, anywhere in the world. Future signal-capture environments will range from urban areas to outer space. The program will transition via industrial performers. *FY 2010 Plans:* - Improve rejection of unwanted signals while minimizing impedance. - Match resonators to analog-to-digital converters.				
Chip-Scale Vacuum Micropumps (U) The ability to efficiently distribute fluids throughout certain types of microsystems and to provide on-chip vacuum capabilities for various technologies is critical to the performance of many microsystems, including micro mass spectrometers, nanoscale detectors, RF resonators, and vacuum microelectronic components. Although microscale pumps have been developed by a number of research groups, many microsystems currently employ off-chip pumping because available microscale pumps cannot meet stressing application requirements. There is a pressing need for chip-scale micropumps with significantly improved performance (capable of operating at ~10^-6 Torr in a volume smaller than 1 CM^3). The MEMS Micropumps program will develop high-performance pumping capabilities critical to achieving an integrated, low-power microscale total analysis system and other complex electronic devices. The program will transition via industrial performers. *FY 2010 Plans:* - Develop methods to increase compression ratio and pump speeds to MEMS scales. - Decrease size of on-chip vacuum pumps.	0.000	0.000	4.000	
ChipScale Micromechanical, Efficient Deep-sub Wavelength Antennas (U) ChipScale Micromechanical, Efficient Deep-sub Wavelength Antennas will pursue development of integrated antennas directly on top of RF Complementary Metal-Oxide Semiconductor (CMOS) chips for optimal power transfer and impedance matching. MEMS high frequency resonators can be arrayed to generate an impedance matched surface to incident electromagnetic fields, while at the same time realizing differential detection by resonators that generate different phases at the incident frequencies. Scaling of resonators can be readily used to realize antennas tuned at different frequencies from kHz, MHz	0.000	0.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
to X-band, and at different quality factors for designable antenna efficiency and directionality. The program will transition via industrial performers. *FY 2010 Plans:* - Employ metrology data to predict device performance using nanoscale Computer Aided Design (CAD) tools, and apply tuning to achieve homogeneous.				
Nano Thermal Interfaces (NTI) (U) The primary goal of the Nano Thermal Interfaces (NTI) program is the development and demonstration of new technologies and concepts based on exploitation of novel materials and structures that provide significant reduction in the thermal resistance of the interface layer between the backside of an electronic device (chip) and the next layer of packaging. This interface is where considerable waste heat is dissipated and leads to thermal limitations in many electronic components. The NTI program will develop new materials and associated processes to serve as enhanced thermal interfaces that can provide consistent, reliable and stable thermal resistance throughout the life of DoD electronic systems. Materials with highly directional thermal properties and matched thermal coefficients will be investigated and utilized. Program transition will occur through industrial performers. *FY 2009 Plans:* - Investigate new approaches for the development and fabrication of high performance thermal interface materials. *FY 2010 Plans:* - Investigate novel materials and fabrication approaches for high-performance thermal interface materials with appropriate electronic materials and substrates.	0.000	4.000	6.810	
Active Cooling Modules (ACM) (U) The Active Cooling Modules (ACM) program will enable greater power utilization margins in electronic materials while also increasing device reliability. Technologies developed will focus on lower temperature	0.000	0.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
operation of sensitive components, including operation below ambient temperatures. It will also leverage gains from other DARPA thermal and materials programs. *FY 2010 Plans:* - Design and build modules with all interfaces that demonstrate ACM benefits. - Reduce junction temperature for electronic devices.				
Chip-Scale Micro Gas Analyzers (U) The Chip-Scale Micro Gas Analyzers program utilized the latest microelectromechanical systems (MEMS) technologies to implement separation-based analyzers (e.g., gas chromatographs, mass spectrometers, poly-chromator-like devices) at the micro-scale to greatly enhance the selectivity of sensors to specific species, and thus, enable extremely reliable, remote detection of chemical/biological agents. The use of MEMS technology also increased analysis speed and made possible the operation of such complex analyzer systems at extremely low power levels-perhaps low enough for operation as autonomous, wireless sensors. The many challenges faced in this program included the exploration and realization of micro-scale preconcentrator approaches, stacked gas columns, multiple sensor arrays, ionizers, vacuum pumps, and vacuum packaging. The success of this program yielded sensors substantially more selective than conventional sensors, again, making them particularly suitable for detection and identification of airborne toxins. The Chip-Scale Gas Analyzers program is transitioning via industry to Chemical Warfare Agents (CWA) detector programs being developed by the Defense Threat Reduction Agency (DTRA) and the Army Soldier and Biological Chemical Command (SBCCOM). *FY 2008 Accomplishments:* - Demonstrated MEMS-enabled, micro-scale separation columns, ionizers, electromagnetic field generators, vacuum pumps, gas sensor arrays, calibration sources, all needed for separation-based analyzers. - Demonstrated advanced methods for making micromechanical sensor elements species sensitive (e.g., combinations of absorption spectroscopy and resonators coated with species-and-light sensitive films). - Implemented fully functional, MEMS-enabled gas separation analyzers with power consumptions small enough for autonomous, remote operation and control electronics integrated directly.	1.112	0.000	0.000	

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C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-15: MIXED TECHNOLOGY INTEGRATION	124.411	128.489	127.949						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The goal of the Mixed Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems. These ‘wristwatch size’, low-cost, lightweight and low power microsystems will improve the battlefield awareness, security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: microelectromechanical systems (MEMS), microphotonics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, and requires fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form batch-fabricated, mixed technology microsystems ‘on-a-single-chip’ or an integrated and interconnected ‘stack-of-chips’.

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

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using ‘standard’ processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/ nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and ‘multiple-chip-scale’ packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotonics, microelectronics and microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume, and cost of weapon systems while increasing their performance and reliability.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Adaptive Photonic Phased Locked Elements (APPLE) (U) The goal of the Adaptive Photonic Phased Locked Elements (APPLE) program is to demonstrate a fully scalable and modular architecture of phased sub-apertures capable of producing an arbitrarily large optical aperture that can be rapidly and non-mechanically steered over a wide field of regard with high precision. This effort is anticipated to transition via industry for potential laser systems and space based applications. *FY 2008 Accomplishments:* - Demonstrated the controlled combining of the outputs of multiple (7) small individual apertures at low input powers. - Demonstrated a small single aperture that could handle a high level of input laser power (200 Watts). *FY 2009 Plans:* - Demonstrate high power combined output of multiple (7) small individual apertures. *FY 2010 Plans:* - Demonstrate atmospheric compensation in the real atmosphere at low powers.	12.314	6.792	13.000	
Data in Optical Domain Network (DoD-Network) (U) Currently, optical networks use photonics to transport data and electronics to process data. However, as the underlying bit rates of the optical networks are pushed beyond 40 giga-bits per second there will be significant processing bottlenecks in these networks and these bottlenecks will severely limit the military's ability to rapidly transport time critical information. A potential solution to this problem is to develop photonic technology so optics can take over higher order network processing functions. The Data in Optical Domain Network (DoD-Network) program will develop and demonstrate four key photonic technologies to meet these challenges: all-optical routing, all-optical data buffering (controllable and eventually random access), optical logic and circuits, and all-optical (multi-wavelength) regenerators. These photonic technologies will lead to intelligent all-optical networks. The program will have two major areas of interest: the first will focus on developing new photonic technology that is essential if photonics	9.539	3.693	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
is to play a significant role in higher order processing in optical networks, the second area will focus on developing novel architectures that will fully exploit the new photonic technology to bring new and increased functionalities to the optical networks. The DoD-Network program is anticipated to transition via industry to high speed, high capacity optical networking programs of interest to the Air Force. *FY 2008 Accomplishments:* - Demonstrated all-optical, Indium Phosphide (InP)-based, integrated photonic, packet forwarding chip which supports forwarding and re-labeling of optical packet headers. - Demonstrated the first fully monolithic separate absorption and modulation wavelength converter operating "error-free." *FY 2009 Plans:* - Develop an all-optical data router (ODR) with high data rate ports. *FY 2010 Plans:* - Demonstrate an ODR with high-throughput, multiple input/output ports, high signal integrity, high signal-to-noise ratio and high scalability leading to an intelligent all-optical network. - Test interoperability of an ODR with electronic routers.				
High Operating Temperature - Mid-Wave Infrared (HOT MWIR) (U) The objective of the High Operating Temperature - Mid-Wave Infrared (HOT MWIR) program is to establish technology for high-speed sampling and high-spatial resolution infrared focal plane arrays that operate in the mid-wave infrared without cryogenic cooling. The high sampling speed is required for both threat detection and for imaging from fast moving platforms. Technology goals are to achieve greater than an order of magnitude reduction in currents contributing to detector noise demonstrated with a high density, large area detector array format of up to 1280 x 720 elements. For imaging, the sensor will respond in a broad spectral band, including the mid and long wave infrared, and will be optimized for imaging at high frame rates with large field of view. This program is anticipated to transition via industry for applications such as multi-band mid-wave or micro-detectors.	14.405	10.374	9.126	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Demonstrated 256x256 arrays operating at 250 Kelvin with X8 – X10 lower dark current. - Established pixel design and test arrays for mega-pixel room temperature arrays. - Demonstrated high density arrays with dual band (mid/long wavelength infrared) response. *FY 2009 Plans:* - Demonstrate thermal array with novel pixel structure showing low thermal mass and reduction in low frequency noise. - Demonstrate mid-wave photon detector array with dark current reduced to be comparable to the current from background radiation. *FY 2010 Plans:* - Demonstrate large format mid-wave photon detector array operating at elevated temperature. - Demonstrate high pixel density broadband (mid-wave and long-wave) thermally sensitive array with fast thermal time constant to increase frame rate.				
Visible/Short Wave IR - Photon Counting (U) The Visible/Short Wave IR - Photon Counting program will develop imaging over a broad spectral band at extremely low levels of ambient illumination to provide a unique capability for remote sensing, unattended sensors, and pay-loads for autonomous ground and air platforms. Recent innovations in solid state imaging devices, including parallel processing at the pixel level and novel read read-out technology, can contribute to development of a new class of sensors, which can create an image with only a few photons per pixel, exceeding performance of current low light level imagers. The direct conversion of low light level information into an electronic format provides access to a suite of signal processing, image enhancement and communications techniques not available with current low light level imaging devices. This program will transition via industry for ultraviolet to infrared imaging applications. *FY 2008 Accomplishments:* - Demonstrated read-out integrated circuit for short wave infrared with less than 10 noise electrons.	7.297	1.004	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Integrated low noise focal plane array into a mega-pixel array format and demonstrated room temperature imaging. *FY 2009 Plans:* - Demonstrate single photon counting devices for ultra low noise imaging.				
Electronic & Photonic Integrated Circuits on Silicon (EPIC) (U) The Electronic & Photonic Integrated Circuits on Silicon (EPIC) program will develop two critical alternative photonic technologies based on silicon substrates. The first thrust addresses active photonic components based on silicon, which do not rely on generating light within the material. While passive photonic components, such as waveguides, can be fabricated from silicon, silicon's indirect bandgap does not lend itself to fabricating active photonic components based on the generation of photons (lasers, amplifiers etc.). The first alternative technology development will be optical amplifiers using Raman gain. Fiber amplifiers based on Raman gain currently play a major role in optical networks, and demonstrating this optical amplification in silicon will be a major step toward overcoming on-chip losses in complex chip-scale optical components. The second alternative technology development will address optical transistor action, or switching, in silicon (i.e., a three-terminal optical device in which control photons at one terminal will make a large change in the photons transmitted between the other two terminals). Taken together, these two capabilities will create a new paradigm in which silicon will provide a platform for monolithic integration of photonic and electronic functions. The EPIC program is anticipated to transition via industry to optical communication and electronic warfare programs of interest to all Services. *FY 2008 Accomplishments:* - Demonstrated 40 gigabytes per second capacity transceiver chip with four wavelengths. - Demonstrated a wideband radio frequency channelizer with multiple channels and nulling of at least a single channel. - Increased integration complexity of electronics and photonics to include hundreds of photonics components.	5.866	1.125	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Demonstrate a functional Application Specific-EPIC using complementary metal-oxide semiconductor (CMOS) compatible processing.				
Space, Time Adaptive Processing (STAP) BOY (U) The Space, Time Adaptive Processing (STAP) BOY program will research, develop, and demonstrate miniature, low-power, low-cost, teraflop-level signal processing solutions derived from commercial Graphics Processor Unit (GPU) hardware and software of the type currently used for fast geometry computations in hand-held electronic games like Nintendo's GAME BOY (Registered Trademark). Success in this program will allow the DoD to exploit the continuing phenomenal growth in both performance and programmability of GPUs resulting from competition in the multi-billion dollar international electronic entertainment industry. Particularly relevant advantages of recent GPUs over more traditional embedded processors include enhanced memory access bandwidth, hardware-accelerated floating-point vector geometry functions, low power consumption, and open source programming language support. The STAP BOY technology will transition to the Army at the conclusion of Phase III. *FY 2008 Accomplishments:* - Demonstrated that the prototype system is capable of sustaining 100 giga floating point operations per second (Gflops) potentially scalable to a multi-GPU pipeline mesh teraflop computing architecture, and is easily programmable to provide extremely high performance in diverse challenge problems. *FY 2009 Plans:* - Develop and test military application prototypes utilizing STAP-BOY technology. - Develop a self-programming capability for this technology.	4.240	5.500	0.000	
Analog Spectral Processors (ASP) (U) The Analog Spectral Processors (ASP) program will leverage existing MEMS capabilities to make precision RF components, and perform low-insertion-loss/heterogeneous components integration to demonstrate integrated Analog Spectral Processors that greatly reduce dynamic range and bandwidth required on analog/digital converters and other front-end components. This will enable proliferation of	4.325	9.028	6.289	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
advanced RF capabilities to the individual war fighter by dramatic reduction in size, weight, and power of RF systems. Industrial firms that are currently the major suppliers of radio equipment for defense and homeland security applications will serve as the primary transition partners upon successful completion of the program. *FY 2008 Accomplishments:* - Demonstrated intimate integration of filter and switch components. - Demonstrated pre-selector, intermediate frequency, and analog filter sensor banks. - Completed Conceptual Design Review. *FY 2009 Plans:* - Integrate filter banks with active components. - Conduct analysis of proposed front-end architecture. - Breadboard-level filter banks will be delivered to a third-party testing facility. *FY 2010 Plans:* - Demonstrate a complete Analog Spectral Processor front-end meeting size, power and performance objectives.				
Electromagnetic Pulse Tolerant Microwave Receiver Front End (EMPIRe) (U) The Electromagnetic Pulse Tolerant Microwave Receiver Front End (EMPIRe) program will create a wide bandwidth, tunable RF front end technology that is immune to electromagnetic pulse (EMP) attack. This program will seek an entirely new approach to RF front-end technology where all metal and front-end electronic circuitry are eliminated. Of particular interest will be an all-dielectric, electronics-free RF front end with sensitivity and dynamic range consistent with today's wireless communication and radar systems. A secondary goal is to effect a significant reduction in detectable radar cross section by eliminating the metallic antenna. (U) EMPIRe represents the ultimate solution for protecting wireless communication and radar systems. EMPIRe can find immediate application protecting tactical communication and radar systems, which	2.109	5.690	5.220	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
are highly vulnerable to EMP attack due to their close proximity to enemy assets. As the efficiency and tunability of the all-dielectric non-electronics front-ends improve, the technology can become an ubiquitous RF front-end for all military as well as commercial wireless devices, providing the communications infrastructure immunity against EMP attacks. This program will transition through industry performers involved with reducing the susceptibility of electronics to damage from high EMP weapons. *FY 2008 Accomplishments:* - Designed and implemented doubly resonant (RF and optical) antenna structures in support of non-electronic signal transduction. *FY 2009 Plans:* - Demonstrate dramatic reduction in RF front-end susceptibility to electromagnetic pulses while maintaining militarily useful system. *FY 2010 Plans:* - Design and simulate microwave receiver front-end and model high power microwave exposure; predict robustness limits based on microwave power handling capability. - Fabricate front-end and test RF performance. - Experimentally validate power handling capability.				
Microsensors for Imaging (MISI) (U) The Microsensors for Imaging (MISI) program establishes technology for extremely small, lightweight cameras sensitive in the short wave infrared spectrum for a wide range of applications. MISI is initially focused on two important areas, micro-air vehicles and a head-mounted system. The camera components comprise a micro-system including optics, focal plane array and electronics with display, energy source and illuminator included as the head-mounted system. The limitation of weight and power places demands on the sensor technology for exceptional image quality in a micro-package. This technology will have many DoD applications. In the micro-air vehicle application, the weight goal is ten grams (including the optics, detector and electronics) for a camera with a degree field of view and recognition range of 100 meters. In the head-mount application, the weight goal of 350 grams includes the sensor with display	4.428	4.917	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
and power source. This program will transition through industry performers into DoD systems, allowing integration into small robotic platforms and micro-air vehicles. *FY 2008 Accomplishments:* - Demonstrated imaging arrays in micropackage for both man-portable and micro-vehicle applications, with package thermal stability for long-lifetime operation. - Completed design of short wave arrays for helmet mounted applications compatible with illuminator and compact system design. *FY 2009 Plans:* - Demonstrate megapixel arrays in micropackage that amplify low level optical signals with minimum excess noise while maintaining uniformity across the array. - Demonstrate operation at room temperature over military temperature range.				
Maskless Direct-Write Nanolithography for Defense Applications (U) The Maskless Direct-Write Nanolithography for Defense Applications program will develop a maskless, direct-write lithography tool that will address both the DoD's need for affordable, high performance, low volume Integrated Circuits (ICs) and the commercial market's need for highly customized, application-specific ICs. In addition, this program will provide a cost effective manufacturing technology for low volume nanoelectromechanical systems (NEMS) and nanophotonics initiatives within the DoD. Transition will be achieved by maskless lithography tools, installed in the Trusted Foundry and in commercial foundries, which will enable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems. *FY 2008 Accomplishments:* - Designed, built, and integrated a demagnification optics system and wafer adapter, and achieved a patterning resolution on the wafer of about 1 micron. - Characterized prototype Reflection Electron Branch Lithography (REBL) system to validate simulation results.	24.700	19.000	27.100	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Demonstrate rotary stage at 10 meters per second. - Demonstrate static imaging on prototype REBL system. - Demonstrate dynamic imaging on prototype REBL system. *FY 2010 Plans:* - Design, build, and test a rotary stage. - Demonstrate System Level Lithography Performance on a Linear Stage Demonstrator System. - Integrate electron beam column and rotary stage demonstrator platform. - Design, build, and characterize an enhanced electron beam column for system alpha prototype experiments.				
Stand-off Solid Penetrating Imaging (U) The Stand-off Solid Penetrating Imaging program detected and identified explosive threats at a stand-off distance, a critical requirement for force protection in all military operations, especially in urban scenarios. Using a microsystem approach, it identified and exploited significant attributes from multiple non-over-lapping perspectives, such as shape and chemical signature, at stand-off ranges of fifty meters to potentially one hundred meters. *FY 2008 Accomplishments:* - Assessed X-ray source requirements, such as power, size, weight, focal spot, and tube configuration including various beam formation techniques. - Implemented X-ray imaging reconstruction for remote vehicle applications.	2.542	0.000	0.000	
Deep Ultraviolet Avalanche Photodetectors (DUVAP) (U) This program will demonstrate avalanche photodiodes (APDs) operating in the Geiger mode, i.e. capable of counting single photons with high gain. The APDs will operate in the ultraviolet, in the band centered at 280 nanometers (nm), and will be designed to be insensitive to the solar flux. The two classes of materials being pursued are Silicon Carbide (SiC) and Aluminum Gallium Nitride (AlGaN). The U.S. military has a need for compact, reliable, and cost-effective Geiger-mode photodetectors. Avalanche	3.833	1.139	1.720	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
photodetectors offer high gain, low dark count, high reliability and robustness, and small form factor needed in future military applications. Technology will transition via industry. *FY 2008 Accomplishments:* - Demonstrated Geiger mode operation of an APD at 280 nanometers. - Determined maximum defect density for stable avalanche gain. *FY 2009 Plans:* - Demonstrate integrated solar-blind ultraviolet filter with appropriate cutoff. - Optimize materials for low defect density and reproducible device yield. *FY 2010 Plans:* - Demonstrate a large array of Geiger mode APDs with dark count rate < 10 kilohertz (kHz) and high solar rejection ratio (over 1,000,000).				
Ultradense Nanophotonic Intrachip Communication (UNIC) (U) The goal of the Ultradense Nanophotonic Intrachip Communication (UNIC) program is to demonstrate nanophotonic technology for access to on-chip ultra-dense systems and Input/Output (I/O) to/from a chip containing such ultra-dense systems. Technical challenges that must be met include: high precision, low loss nanophotonic circuit fabrication; low cost fabrication methods; high performance nanoscale modulators; detectors, multiplexers and demultiplexers; architecture for addressing ultra-dense systems; and techniques for efficient high capacity/bandwidth I/O of data to and from the chip. This technology will transition via industrial performers developing faster and more complex processing such as real-time pattern matching, target recognition, image processing and Terahertz (THz) class command-and-control networks. *FY 2008 Accomplishments:* - Created novel designs to demonstrate extremely low power complementary metal-oxide-semiconductor (CMOS) compatible silicon photonic devices.	3.127	10.950	11.970	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Demonstrate extremely low power CMOS-compatible silicon photonic devices that demonstrate a path to on-chip optical communication links that are superior to conventional electronic messaging in single-die multiprocessor computing architectures. - Integrate arrays comprised of 4-wavelength silicon photonic transmitters and 10 gigabytes/second receiver. *FY 2010 Plans:* - Demonstrate integrated arrays of 4-wavelength silicon photonic transmitters and receivers operating at 10 gigabytes per second (Gbps). - Demonstrate feasibility of 1.5 per Joule/bit interconnect link energy budget for silicon photonic optical data link, based upon fabricated arrays. - Demonstrate wavelength division multiplexed routing through 2 physical layers at 10 Gbps and less than one part in a trillion bit error rate (1E-12 bit error rate).				
Hemispherical Array Detector for Imaging (HARDI) (U) The objective of the Hemispherical Array Detector for Imaging (HARDI) program is to exploit the benefits of the hemispherical imaging surface. The basic idea behind the program is that a detector array can be fabricated on a hemispherical substrate using materials such as organic/inorganic semiconductors and that this array can be combined with a single lens to produce a wide field of view, small form factor camera. Organic materials have been shown to have good electronic and optoelectronic properties including light emission and detection. Furthermore, in-plane organic/inorganic transistors can be incorporated for pre-processing of images. This program will transition to eventual DoD systems through a demonstration of an array prototype developed by industrial contractors. *FY 2008 Accomplishments:* - Developed high efficiency detector materials. - Demonstrated curved single pixel detector.	8.386	6.575	6.519	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Develop improved materials for Visable-Near IR-Shortwave IR (VIS-NIR-SWIR). - Demonstrate a curved focal plane array. *FY 2010 Plans:* - Develop novel photodetector materials for the spectral range 400-1900 nanometers (nm). - Demonstrate a 16,000 pixel array on a 2.5 cm radius hemispherical substrate. - Explore manufacturing techniques amenable to producing hemispherical array detectors with high reproducibility.				
Dual-Mode Detector Ensemble (DUDE)* *Formerly titled Day/Night Adaptive Imager. (U) The Dual-Mode Detector Ensemble (DUDE) demonstrates the integration of an uncooled long wave infrared sensor (LWIR) (8-12 microns) with a sensor that operates in the Visible/Near Infrared/SWIR (VNS) (0.4-1.6 microns) spectral range. The integration of this combined day/night focal plane with the broad spectral band flat-format optics will realize a compact day/night rifle sight system. The combined sensor will provide the soldier with the ability to utilize aiming lights registered with the thermal image, see through windows with the reflected light sensors, identify people at night, and see targets on the battlefield designated from other sources, while reducing the logistics burden and weight they have to carry. These together would be a major paradigm shift in the technology. The demonstration array will be a large format long wave infrared array operating at room temperature with four reflected light pixels for each long wave pixel, and evaluated for rifle sight applications. The technology will transition via industry upon successful completion of the program. *FY 2008 Accomplishments:* - Developed ultra-wide dynamic range imaging sensors that count individual photon events and also operate in high light level.	3.500	5.000	7.834	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Reduce dark counts for room temperature operation. - Demonstrate integrated functions, such as day/night imaging with covert signal detection. *FY 2010 Plans:* - Build 640x512 infrared array integrated with a Visible/Near-IR/Short-wave IR (VNS) array. - Demonstrate VNS array with the pixels meeting dark current of 50 na/cm^2 at 10 degrees C. - Demonstrate aiming lights co-registered with the infrared array.				
Nyquist-Limited Infrared Detectors (NIRD)* *Formerly High Resolution Short Wave Infrared/High Density Infrared Retina. (U) The Nyquist-Limited Infrared Detectors (NIRD) program develops high density, long-wave infrared (LWIR) arrays and signal processing to improve capability to image through scattering media such as dust and sand, known as brownout, fog, snow storms, and to enhance situational awareness needed for aircraft navigation. The LWIR provides advantages in imaging through the dust clouds created in helicopter landing especially in desert areas. This obscurant penetration capability of LWIR imaging can be significantly improved when the pixel size is reduced to preserve high frequency information, while at the same time, a practical size optical aperture is maintained with approximately F/1 optics. The obscurant penetration capability of the LWIR focal plane array (FPA) can be further enhanced with signal and imaging processing. The low frequency pedestal in the image caused by the obscurant must be reduced to increase image contrast and the effective dynamic range. The small pixel FPA presents unique challenges in detector design and fabrication and in the interconnection of the detector array to the read-out integrated circuit (ROIC). The origin of noise currents in the detector must be understood and characterized, especially the role of surface currents in the small pixel devices. The method of interconnection must be compatible with large arrays of small pixel elements, achieve a low contact resistance, and reliably interconnect at each pixel across the array. This program will transition via industry upon successful completion.	0.000	3.800	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop new detector approaches for high pixel density with passivation processes to control surface leakage, which will dominate small detectors. - Demonstrate test structures with detector size approaching two microns and show contact method to small pixel structure. - Conduct feasibility study incorporating the results from the static runway measurements, outside data collection sources, and dynamic flight tests. - Develop requirements to support the development of a high resolution sensor pertinent to limited visibility flight operations. *FY 2010 Plans:* - Demonstrate LWIR detectors, with a size of 5 micrometers, operating at 80K with dark current less than 0.5ma/cm^2. - Achieve 10 x 10 LWIR array with 5 micrometer pixels interconnected to silicon read-out with interconnect resistance less than 5 ohm.				
Photon Trap Structures for Quantum Advanced Detectors (P-SQUAD) (U) The objective of Photon Trap Structures for Quantum Advanced Detectors (P-SQUAD), which was previously funded as part of the Nyquist-Limited Infrared Detectors program, is to develop technologies for fabrication of multi-stacked and multi-functional nano-pillar materials structures for various new and improved devices. The main objective is to develop a process technology that allows fabrication of nano-pillar stacked architectures of at least three different semiconductor materials for multi-spectral infrared (IR) detector technology. This technology will transition via the program's industrial performers. *FY 2009 Plans:* - Fabricate 16 x 16 detector arrays using nano-pillar arrays. - Validate P-SQUAD structure design characteristics using experimental and theoretical models. *FY 2010 Plans:* - Demonstrate a 640 x 480 array that is fully integrated with readout processor.	0.000	4.518	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Validate P-SQUAD integrated array design.				
Disruptive Manufacturing Technologies (DMT) (U) The goal of the Disruptive Manufacturing Technologies (DMT) program is to achieve significant and pervasive cost savings, and/or decreases in cycle time, for existing or planned procurements. There has been a long-standing desire to replace traveling wave tube amplifiers (TWTAs), which are pervasive in nearly all electronic warfare (EW), information warfare (IW), radar, and communication systems with lower cost solid-state components. The DMT program will merge Polystrata (Registered Trademark) and GaN technologies to eliminate the need for monolithic microwave integrated circuits (MMICs). The direct product replacement transition candidate for this program is the TWTA power amplifier output stage in the AN/ALE-55 Fiber Optic Towed Decoy for the Navy's new F/A-18 E/F Super Hornet, and the Air Force B1-B and F-15 platforms. It will be replaced with solid-state hybrid microwave integrate circuit (HyMIC) modules developed by merging Polystrata and gallium nitride (GaN) technologies. The result will be a 10x reduction in TWTA cost for the Integrated Defensive Electronic Countermeasures (IDECM) program, a joint Navy-Air Force program. Beyond developing a replacement for TWTAs, HyMIC technology promises to increase adoption of high performance millimeter wave (MMW) systems employing mature III-V technologies as well as advance earlier adoption of those using nascent III-V technologies. The program will transition into the joint Navy-Air Force IDECM program. *FY 2008 Accomplishments:* - Demonstrated flip chip mounting on Polystrata structures. - Completed proof-of-concept GaN 20 watts (W) module implemented with Polystrata technology, along with a passive element library to enable development of the 57 W GaN building block. *FY 2009 Plans:* - Demonstrate a form-fit-function 160 W GaN amplifier ready for insertion into the IDECM decoy module. *FY 2010 Plans:* - Demonstrate 57 W GaN HyMIC building block.	4.368	2.392	1.418	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continue to demonstrate a form-fit-function 160 W GaN amplifier (TWTA replacement) ready for insertion into the Integrated Defensive Electronic Countermeasures (IDECM) decoy module.				
COmpact Ultra-stable Gyro for Absolute Reference (COUGAR)* *Previously reported in PE 0603768E, Project GT-01. (U) The COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) program goal is to realize the fundamental performance potential of the resonant fiber optic gyro (RFOG) in combination with bandgap optical fiber (BGOF), ultra-stable compact lasers, phase conjugate elements (PCEs), and silicon optical benches: a compact ultra-stable gyro for absolute reference applications. The COUGAR gyro will have a practical and typical size (~ 4 inch diameter) featuring bias stability and sensitivity (or angle random walk), which is more than 100 times better than state-of-the-art gyroscopes. *FY 2009 Plans:* - Develop purely single-polarization low-loss, low glass-content BGOF. - Demonstrate compact narrow line-width single-frequency laser technology with ultra-low jitter and the capability of extremely linear frequency scanning. - Develop resonator-ready (low-loss) PCEs for mitigating residual non-linear Kerr Effect errors and relaxing tolerances on laser intensity stabilization requirements. - Develop silicon optical bench technology for optical ruggedization and a path toward a compact and affordable gyroscope. *FY 2010 Plans:* - Initiate development of optical bench interface technology for the air-to-bandgap fiber to then be exploited for a gyroscope with reasonable bias performance levels and consistent with military needs.	0.000	5.761	7.285	
Gratings of Regular Arrays and Trim Exposures (GRATE)* *Formerly Cost Effective Low Volume Nanofabrication.	0.000	4.448	6.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Gratings of Regular Arrays and Trim Exposures (GRATE) program will develop revolutionary circuit design methodologies combined with hybrid lithography tools to enable cost-effective low volume nanofabrication for DoD applications. Moore's law has driven the silicon industry for several decades with the minimum feature size on an integrated circuit (IC) reduced to 45 nm for today's commercial products. Due to challenging patterning requirements and complex circuit designs, costs of lithography tools and masks have become unaffordable for low-volume manufacture, i.e., military electronics or application specific integrated circuit (ASICs). Similarly, the circuit design, verification, and testing costs have also grown exponentially further preventing military electronics from using advanced silicon technology nodes. Military electronics capabilities are currently limited by the high cost of nanofabrication. To solve this important problem, DARPA has invested in a variety of maskless patterning technologies including parallel e-beam arrays, parallel scanning probe arrays, and an innovative e-beam lithography tool. This program will develop revolutionary circuit design methodologies coupled with innovative hybrid maskless patterning tools to realize cost-effective nanofabrication for low-volume defense or commercial ASICs. Such an approach can also address the nanofabrication requirements of other low-volume DoD technologies such as photonics and micro-electro-mechanical systems. This program will transition via industry. *FY 2009 Plans:* - Develop 1D-Designs and Patterning Methods. - Evaluate the efficacy of regular geometry templates for improving lithographic performance for more robust imaging, simplified design/layout process, and increased throughput for maskless lithography methods. - Verify efficacy of 1D design approach. Quantitative benefits of 1D vs traditional 2D design approach. 2D to 1D conversion of legacy design IP. - Develop 1D design enabling process extensions such as “trim/stitch” and “frequency doubling”. 1D test cell fabrication. - Study feasibility of custom grating fabrication tool based on interference lithography. *FY 2010 Plans:* - Develop 1D Fabrication Demos.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Develop 1D standard cell library for digital designs at < 32 nm node. 1D computer aided design tool development. - 1D fabrication demos including various circuit elements making use of 1D-specific process extensions. - Demonstrate 1D circuit patterns using trimmed interference lithography.				
Room Temperature Spintronics-Based Logic (Spin Logic) (U) The goal of the Room Temperature Spintronics-Based Logic (Spin Logic) program is to develop room temperature logic devices based on magnetic spin. In current logic devices, the ultimate speed is limited by the heat that can be removed from the chip. The current microchip technology has been shown to be highly optimized for efficiency and no significant decreases in energy per logic step are possible outside of those already on the technology roadmap. Devices based on magnetic spin would not be based on the movement of electrical charge and can therefore operate at a reduced energy cost per logic function while retaining the performance of the current technology. It is expected that the Spin Logic program will lead to both higher performance logic chips, and lower power electronics. *FY 2010 Plans:* - Explore techniques to efficiently generate, manipulate and detect magnetic spin waves.	0.000	0.000	5.000	
Advanced Photonic Switch (APS) (U) The objective of the Advanced Photonic Switch (APS) program (an outgrowth of the Ultradense Nanophotonic Intrachip Communication (UNIC) program) is to develop a technology for creating on-chip, photonic switching devices which can be fabricated in a silicon-compatible process. Most high performance photonic switching devices are fabricated with compound semiconductors, but silicon manufacturing technologies now offer potential advantages due to the great precision being driven by commercial mainstream markets for microelectronics. This program is pursuing advanced technologies that will take full advantage of those commercial capabilities but will exploit them to produce photonic devices that maximize switching speed, minimize device power dissipation and transmission losses, small area, and decreased sensitivity to ambient temperature variations. The photonic switches developed in this program will be spectrally broad-band, capable of simultaneously switching multiple, high bit-rate wavelength channels, and scalable to complex port switches. The switching devices developed in APS	2.063	1.930	1.468	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
will benefit low power, high bandwidth, low latency, photonic communications networks, thereby benefiting a broad array of U.S. Department of Defense (DoD) problems and the larger U.S. National interests in network-based activities. APS will transition to industry. *FY 2008 Accomplishments:* - Finalized the design and operation of the first generation of Nanophotonic Optical Broadband Switches (NOBS). - Completed physical design activities for first generation NOBS and initiated fabrication of masks. *FY 2009 Plans:* - Complete fabrication of prototype NOBS devices to create a 2x2 array. - Design, fabricate, and test silicon complementary metal-oxide semiconductor (CMOS) driver circuits that can be integrated with NOBS. *FY 2010 Plans:* - Enhance APS fabrication technologies and design approaches to improve the NOBS devices and integrated assemblies.				
Channelized SIGINT and ELINT Receiver for UAV Applications (ChaSER) (U) The objective of the Channelized SIGINT and ELINT Receiver for UAV Applications (ChaSER) study was to design, develop, and characterize a photonic Radio Frequency (RF) receiver front-end to reduce the size, weight and power (SWAP) of Electronic Support Measures/Electronic Counter Measure (ESM/ECM) systems by 100,000 times while maintaining or improving RF performance levels. *FY 2008 Accomplishments:* - Initiated the development of a highly sensitive, ultra-light, ultra-wideband, radar intercept and location system.	3.472	0.000	0.000	
Ultra Low Power Electronics for Special Purpose Computers	1.040	1.600	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) This program is developing advanced computing technology utilizing very low power electronic devices. *FY 2008 Accomplishments:* - Developed low power nanoscale electronics for special purpose computers. *FY 2009 Plans:* - Continue low power nano scale electronics development.				
Computing and Nanoscale Electronic Processing (U) The main objective of this program was to explore computing and nanoscale electronic processes. *FY 2008 Accomplishments:* - Developed new applications for nanoscale electronics.	1.200	0.000	0.000	
Center for Autonomous Solar Power (U) The objective of this program is to develop autonomous solar power flexible arrays. *FY 2009 Plans:* - Initiate solar power development.	0.000	4.000	0.000	
Adverse Weather Landing System (U) The goal of the Adverse Weather Landing System program is to provide the military pilot with an enhanced visual situational awareness capability to assist in making landing approaches in adverse weather and low visibility conditions. The ability to eliminate poor visibility due to rain, fog, sand storms, and snow storms using electro-optical and signal processing techniques could save lives and loss of aviation equipment. This program will transition via industry.	1.657	2.250	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Collected and analyzed limited visibility data from a variety of sources to develop requirements for a high resolution landing camera system. - Upgraded calibration systems to reduce pattern noise in the infrared (IR) sensors to be used in an operational system for various conditions (haze, sand, fog, snow, and rain). *FY 2009 Plans:* - Conduct feasibility study incorporating the results from the static runway measurements, outside data collection sources, and dynamic flight tests. - Develop requirements to support the development of a high resolution sensor pertinent to limited visibility flight operations.				
Photonic-enabled Simultaneous Transmit and Receive (P-STAR) (U) Information operation missions on multiple military platforms depend on the ability to transmit and receive radio frequency (RF) signals, simultaneously, from a single aperture. This program (a follow on to the Ultra-Wide Band Technology program) aims to develop transmit/receive modules with high transmit-to-receive isolation and low receive noise figures, over a multi-octave bandwidth, to greatly improve situational awareness of the RF environment, and enable greater control over the information domain. Furthermore, this program will help stem the proliferation of "mission-specific" antennas by providing an ultra-wide bandwidth antenna that can substitute for multiple custom antenna solutions. In addition to the increased functionality, the improved noise figure of the P-STAR technology will increase stand-off ranges and provide improved indications and warning. The program will transition via its industrial performers. *FY 2009 Plans:* - Fabricate and demonstrate a STAR module which exhibits high T/R isolation over a multi-octave frequency range. *FY 2010 Plans:* - Develop and demonstrate low loss lithium niobate optical modulators, which exhibit low switching voltages and incorporate a long effective length for achieving high T/R isolation.	0.000	5.803	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Develop and demonstrate a power amplifier that when connected to the electro-optic modulator and incorporated into the T/R module package, enables the transmit power goal over a multi-octave frequency range.				
Hybrid Power Generation System (U) Objective of this program is to advance and explore new hybrid power technologies. *FY 2009 Plans:* - Explore hybrid power technologies.	0.000	1.200	0.000	

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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