Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research					R-1 ITEM NOMENCLATURE PE 0602702E TACTICAL TECHNOLOGY					
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	260.219	352.924	276.075						Continuing	Continuing
TT-03: NAVAL WARFARE TECHNOLOGY	23.207	50.493	25.054						Continuing	Continuing
TT-04: ADVANCED LAND SYSTEMS TECHNOLOGY	53.415	65.891	36.494						Continuing	Continuing
TT-06: ADVANCED TACTICAL TECHNOLOGY	90.867	118.751	88.129						Continuing	Continuing
TT-07: AERONAUTICS TECHNOLOGY	37.067	48.201	50.066						Continuing	Continuing
TT-13: NETWORK CENTRIC ENABLING TECHNOLOGY	55.663	69.588	76.332						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Advanced Tactical Technology, Aeronautics Technology and Network Centric Enabling technologies.

(U) The Naval Warfare Technology project develops advanced enabling technologies for a broad range of naval requirements. Technologies under development will increase survivability and operational effectiveness of small and medium surface vessels in rough seas and demonstrate advanced technologies for hypersonic flight. New areas to be investigated include ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations and predictive tools for small craft hydrodynamic design.

(U) The Advanced Land Systems project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire.

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(U) The Advanced Tactical Technology project is exploring the application of compact and solid state lasers; high performance computational algorithms to enhance signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; precision optics components for critical DoD applications; aerospace electronic warfare systems; new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, and enabling technologies for advanced space systems; and Training Superiority programs that will create revolutionary new training techniques.

(U) The Aeronautics Technology project explores technologies to reduce costs associated with advanced aeronautical systems and provide revolutionary new capabilities for current and projected military mission requirements. This project funds development of micro adaptive flow control technologies; small-scale propulsion system concepts; and a high-strength, low structural weight airlift vehicle designed to control its buoyant lift independently of off-board ballast. New areas to be investigated are reusable hypersonic vehicles; novel helicopter blade designs that reduce acoustic signature; small, low cost high endurance UAV's capable of destroying most enemy UAV's; and short distance take-off and landing of fixed wing aircraft.

(U) The Network Centric Enabling Technology project funds sensor, signal processing, detection, tracking and target identification technology development required for true network-centric tactical operations. Technologies developed in this project will enable localized, distributed and cross-platform collaborative processing so that networks of sensors can rapidly adapt to changing force mixes, communications connectivity and mission objectives. Operational benefits will be smaller forward deployment of image and signal analysts, consistent integration of target and environment information, and flexible operational tactics and procedures for finding evasive targets in difficult environments.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	335.967	371.481	355.591	
Current BES/President's Budget	260.219	352.924	276.075	
Total Adjustments	-75.748	-18.557	-79.516	
Congressional Program Reductions	0.000	-30.957		
Congressional Rescissions	-23.000	0.000		
Total Congressional Increases	0.000	12.400		
Total Reprogrammings	-43.550	0.000		
SBIR/STTR Transfer	-9.198	0.000		
TotalOtherAdjustments			-79.516	

Congressional Increase Details ($ in Millions)	FY 2008	FY 2009
Project: TT-03, **CEROS**	0.000	10.000

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Congressional Increase Details ($ in Millions)	FY 2008	FY 2009
Project: TT-03, **SeaCatcher UAS Launch and Recovery System**	0.000	1.600
Project: TT-04, **Explosively Formed Projectile Iron Curtain**	0.000	0.800

Change Summary Explanation

FY 2008
Decrease reflects Section 8042 rescission, the OSD O&M and AFRICOM reprogrammings, and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and execution delays, offset by congressional increases identified above.

FY 2010
Decrease reflects the transition and completion of several urban operations efforts in the Advanced Land Systems Project (TT-04) as well as completion of Aeronautics Technologies programs in Project TT-07.

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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
TT-03: NAVAL WARFARE TECHNOLOGY	23.207	50.493	25.054						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities such as drag reduction, ship stability, hypersonic missiles, logistically friendly distributed lighting systems, ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations, high speed underwater vessels, improved techniques for underwater object detection and discrimination, long endurance unmanned surface vehicles, and high bandwidth communications.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Hypersonics Flight Demonstration (HyFly)	1.500	1.200	1.000	

(U) The Hypersonics Flight Demonstration program (HyFly) will develop and demonstrate advanced technologies for hypersonic flight. The ultimate goal of the program is to demonstrate vehicle performance that could lead to an operational tactical surface launched missile range of 600 nautical miles. Specifically, the program will demonstrate an F-15 launched missile configuration with a range of 400 nautical miles, a maximum sustainable cruise speed in excess of Mach 6, and the ability to accurately terminate the missile on a GPS guided impact target. Technical challenges include the scramjet propulsion system, lightweight, high-temperature materials for both aerodynamic and propulsion structures, and guidance and control in the hypersonic flight regime. Based on the results of the first two test flights, subsystem components will be modified and a third flight test has been added to the program development schedule.

FY 2008 Accomplishments:
- Conducted Flight 2 at Pacific Missile Test Range; launched from an F-15.
- Completed Flight 2 engine investigation.
- Initiated subsystem design changes.

FY 2009 Plans:
- Conduct testing of modified subsystems.
- Conduct fuel system and nose assembly shock and vibration testing.

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Fabricate major engine components. *FY 2010 Plans:* - Assemble flight vehicle, perform ground testing and check-out. - Conduct third flight test.					
Super-Fast Submerged Transport (U) The Super-Fast Submerged Transport program (Underwater Express) will explore the application of supercavitation technology to underwater vehicles, enabling high speed transport of personnel and/or supplies. The inherent advantages of traveling underwater are: the ability to transit clandestinely, no radar or visible signature, and avoidance of rough sea conditions that may limit or deny mission execution. Supercavitation places the vehicle inside a cavity where vapor replaces the water, and drag due to fluid viscosity is reduced by orders of magnitude, thus reducing the power requirement dramatically. This program will use modeling, simulation, and experiments and testing to develop the understanding of the physical phenomena associated with supercavitation and the application to underwater vehicles. Innovative failsafe controls will be required for stability and maneuverability at speed. The program will culminate in an at-sea demonstration of an unmanned vehicle capable of fully wetted to supercavitating operations and autonomous maneuvering. *FY 2008 Accomplishments:* - Conducted modeling, simulations, and experiments to develop an understanding of cavity and vehicle interactions and the effect of these interactions on vehicle design, control and stability. - Modeled, simulated, and experimentally measured vehicle maneuvering and body forces in a controlled facility. - Developed vehicle and cavity scaling relationships. *FY 2009 Plans:* - Conduct modeling, simulations, and experiments to refine understanding of cavity and vehicle control and stability.		11.707	11.758	11.554	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continue development of vehicle design including propulsion system design and integration, and design, fabrication and testing of a scaled prototype vehicle. *FY 2010 Plans:* - Design, fabricate and commence testing of a scaled vehicle. - Analyze vehicle performance for speed, power and stability.				
Long Range Anti-Ship Missile Demonstration (U) In response to emerging threats, DARPA is building on the technology advances developed under the Hypersonics Flight (HyFly) demonstration program also funded in this project, to develop and demonstrate standoff anti-ship strike technologies to reverse the significant and growing U.S. naval surface strike capability deficit. The Long Range Anti-Ship Missile (LRASM) program will invest in advanced component and integrated system technologies capable of providing a dramatic leap ahead in U.S. surface warfare capability, focusing on organic wide area target discrimination in a network denied environment, innovative terminal survivability in the face of advanced defensive systems, and high assurance target lethality approaches. Specific technology development areas will include robust precision guidance, navigation and control with GPS denial; multi-modal sensors for high probability target identification in dense shipping environments; and precision aimpoint targeting for maximum lethality. Component technologies will be developed, demonstrated, and integrated into a prototype demonstration weapon system. The program will result in high fidelity demonstration to support military utility assessment. Beginning in FY 2010, this program will be funded from PE 0603286E, Project AIR-01, Advanced Aerospace Systems. *FY 2009 Plans:* - Conduct threat modeling. - Complete system performance operations analysis. - Complete analytical trade studies to select seeker and datalink subsystems. - Complete subsystem preliminary designs. - Initiate integrated system preliminary designs. - Commence risk reduction testing of critical seeker, propulsion, and aerodynamic components.	0.000	24.535	0.000	
Extremely Long Endurance Unmanned Surface Vehicle (ELEUSV)	0.000	1.400	3.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Extremely Long Endurance Unmanned Surface Vehicle (ELEUSV) program will evaluate radical large scale unmanned surface platforms with corresponding increases in capability to support high demand naval missions. Current unmanned surface platforms in development are adjuncts to be operated from and in support of conventional manned ships. The next step in full exploitation of this technology is larger scale unmanned vessels that can operate independently at the theater or global level, much like the Global Hawk unmanned air vehicle does today. By focusing on surface platforms that are never intended for a person to step aboard at any point in the operations cycle, an unexplored design space emerges without constraint on structure, stability, or crew support, in contrast to their significant impacts in conventional ship design. The ELEUSV program will explore how those overhead limitations can be converted into meaningful operational performance metrics such as speed, payload, survivability, or reduced construction cost. In order to make these radical ship designs operationally feasible, significant emphasis will be placed on automated maintenance and repair, system operational autonomy and command and control, and payload employment concepts. *FY 2009 Plans:* - Conduct analysis of unmanned naval vessel concepts and operational employment. - Identify core technologies required to enable unique large scale unmanned naval vessel capabilities. - Develop system concept designs and begin platform and payload preliminary design efforts. *FY 2010 Plans:* - Complete system preliminary design. - Demonstrate critical subsystem technologies. - Commence system final design.				
Broad Ocean Demining (U) The Broad Ocean Demining program will develop and demonstrate technologies that allow for the rapid detection and direct neutralization of mines and other asymmetric littoral threats over broad areas. Current mine clearance approaches rely on expendable neutralizers to be placed on each mine target. The operational cost of emplacing each neutralizer demands extensive prior activity to positively differentiate mines from other mine like objects in the operating area, and to precisely locate the mine	0.000	0.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
target so that the neutralizer can be placed within its effective range. By developing technologies that can positively defeat in place mines without reliance on expendable neutralizers, the Broad Ocean Demining program will reduce or eliminate these activities and demonstrate dramatic acceleration of area mine clearance timelines. By eliminating the need for explosive neutralizers, the program will also provide a credible mine clearance capability that can be readily dispersed and employed by military and non-military entities to improve rapid contingency response. Technologies and approaches will be explored for the range of littoral threats to enhance naval force operational freedom and effectiveness. *FY 2010 Plans:* - Identify core technologies to enable affordable and effective defeat of littoral threats. - Develop broad ocean demining architectural concepts and system plans. - Implement selected operational system design efforts. - Conduct risk reduction demonstrations of critical enabling technologies.				
Center of Excellence for Research in Ocean Sciences (CEROS) (U) The Center of Excellence for Research in Ocean Sciences (CEROS) encourages leading edge research and development in ocean sciences by involving highly specialized small businesses with recognized expertise in ocean related research and providing access to potential Department of Navy transition partners. Major research areas of interest have included shallow water surveillance technologies, sensor communications, ocean environmental preservation, new ocean platform and ship concepts, ocean measurement instrumentation, and unique properties of the deep ocean environment. *FY 2008 Accomplishments:* - Completed projects started in FY 2007. - Selected projects for FY 2008 funding. - Contracted for selected projects and monitored progress of ocean related technologies of high interest to the DoD. *FY 2009 Plans:* - Complete projects started in FY 2008.	10.000	10.000	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Select projects for FY 2009 funding.				
Submersible Aircraft (U) This program will combine the speed and range of an airborne platform with the stealth of an underwater vehicle by developing a vessel that can both fly and submerge. The project will exploit lightweight materials, unique dynamic structures and advanced propulsion systems to overcome the technical barriers to achieving this capability. If successful, the project will enable insertion and extraction of special operations and expeditionary forces at greater ranges, and higher speeds, in locations not previously accessible; with minimal direct support from additional military assets. The program goals are to demonstrate a vessel capable of multimodal operations (airborne, surface, and submerged) and that can easily transition between these modes. *FY 2010 Plans:* - Conduct concept designs studies and perform feasibility analysis in order to quantify extent of possible operational envelope. - Identify key technology limitations and performance objectives that need to be overcome in order to achieve concept design.	0.000	0.000	3.000	
Non-traditional Littoral Active Sonar (U) The goal of the Non-traditional Littoral Active Sonar program is to develop solutions for active sonar that do not rely on the use of legacy high-power pulsed sonar. Given the trend of submarine quieting, passive sonar is of diminishing value to the Navy for large area searches. The existing alternatives are high power active sonar systems which are overt and difficult to use in peace time given concerns for the environment. The program will investigate new approaches which exploit acoustic energy spread over space or time as a means to counter the need for high peak power sonar. Once the challenges of low power, complex interference and propagation are overcome, complete new strategies and systems for active sonar will emerge. *FY 2010 Plans:* - Initial phenomenology testing and proof of principal detection demonstrations.	0.000	0.000	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
SeaCatcher Unmanned Aircraft Launch and Recovery System	0.000	1.600	0.000	
FY 2009 Plans: - Explore launch and recovery system concepts.				

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**
TT-04: ADVANCED LAND SYSTEMS TECHNOLOGY	53.415	65.891	36.494						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Guided Projectiles	4.926	3.330	0.000	
(U) The Guided Projectiles program is developing and demonstrating highly maneuverable gun-launched projectiles, and associated fire control and launch systems for employment against critical enemy infrastructure and point targets, such as command, control and communication nodes and radars. This program will develop enabling technologies to give U.S. warfighters the ability to allow weapons platforms, such as mortars, to receive updated target information from other munitions or sense target changes on their own. Based upon this information, the accuracy and effectiveness of the weapons are increased and the potential for collateral damage is reduced. This program will adapt recent advances in communications, computers, sensing and propellants/explosives to demonstrate significant leaps in combat capability. The technologies developed will demonstrate the increased combat effectiveness and the reliability of distributed, collaborative processing and mission execution.				
(U) The program developed low-cost, non-imaging optical seeker/guidance technology exploiting technology development in the visible and infrared spectrum, designed to replace the current 60mm mortar fuse and improve firing precision. Additionally, research was conducted with explosives to improve the effectiveness of 60mm explosive rounds. The goal was to develop a 60mm projectile with the effectiveness of a 105mm high explosive projectile. Technology developed for the 60mm projectile was				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
investigated for application to the 81mm and 120mm mortars to increase the accuracy and effectiveness of all fielded mortar rounds at a low cost. (U) This program will now leverage the innovative low-cost optical seeker technology to develop an affordable fuse-guidance package that converts a conventional 81mm or 120mm mortar round into a precision-guided munition. This program will further extend this development to the development of laser-guided munition systems wing-dropped from tactical UAVs and guidable from the on-board laser designator to any target within the field of view (FOV) of the designator. Critical developments supporting this program include component or packaging development technologies that enable the guidance sensors and actuators to sustain the 20-40,000g peak launch stresses, and the development of guidance systems that integrate low-cost GPS and terminal laser lock-on. *FY 2008 Accomplishments:* - Developed a low-cost optical seeker applicable to 81mm and 120mm mortar rounds and UAV-borne munitions. *FY 2009 Plans:* - Design integration plan for incorporating test seeker-guidance system on large caliber (81mm or 120mm) mortar rounds.					
Recognize Improvised Explosive Devices and Report (RIEDAR) (U) The goal of the Recognize Improvised Explosive Devices and Report (RIEDAR) program is to develop and demonstrate a capability for standoff detection of various devices. *FY 2008 Accomplishments:* - Demonstrated laser filamentation at 100 meters using low power lasers. *FY 2009 Plans:* - Demonstrate operation of compact, tunable lasers from deep ultraviolet (UV) to near infrared (NIR).		3.103	6.704	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Develop integrated sub-system consisting of optical detector and compact laser for detection of explosives.				
Magneto Hydrodynamic Explosive Munition (MAHEM) (U) The Magneto Hydrodynamic Explosive Munition (MAHEM) program will demonstrate compressed magnetic flux generator (CMFG)-driven magneto hydrodynamically formed metal jets and self-forging penetrators (SFP) with significantly improved performance over explosively formed jets and fragments. Explosively formed jets (EFJ) and SFP are used for precision strike against targets such as armored vehicles and reinforced structures. Current technology uses chemical explosive energy to form the jets and fragments. This is highly inefficient and requires precise machining of the metal liners from which the fragments and jets are formed. Generating multiple jets or fragments from a single explosive is difficult, and the timing of the multiple jets or fragments cannot be controlled. MAHEM offers the potential for higher efficiency, greater control, the ability to generate and accurately timed multiple jets and fragments from a single charge, and the potential for aimable, multiple warheads with a much higher EFJ velocity, hence increased lethality precision, than conventional EFJ/SFP. MAHEM could be packaged into a missile, projectile or other platform, and delivered close to target for final engagement. This could provide the warfighter with a means to address stressing missions such as: lightweight active self-protection for vehicles (potential defeat mechanism for a kinetic energy round), counter armor (passive, reactive, and active), mine countermeasures, and anti-ship cruise missile final layer of defense. *FY 2008 Accomplishments:* - Refined existing modeling capability and augmented with new modeling tools to replicate performance of various experiments, allowing identification of issues computationally as well as allowing iteration on initial designs to improve performance. - Continued helical generator (HG) design and fabrication. - Completed component and full unit testing at the Air Force Research Laboratory Chestnut Explosive Test Site. - Designed and tested an end-initiated, shorter, ‘unified’ generator.	3.981	3.705	3.215	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Test a static prototype of a self-contained MAHEM munition to demonstrate the ability to package a MAHEM device into an AT4-CS form factor including setback and jet penetration tests. *FY 2010 Plans:* - Explore additional applications of MAHEM technology including use as a small sized penetrator warhead for both ground-to-ground and air-to-ground anti-armor, localized electronic attack modification, and finally potential as a long range air-to-air/air-to-surface weapon.					
Lightweight Ceramic Armor (LCA) (U) The Lightweight Ceramic Armor (LCA) program leverages recent breakthroughs in novel ceramic fabrication processes developed in the Materials Processing Technology project to drive a dramatic performance shift in the tradeoff between weight and ballistic projectile protection of body armor. Currently fielded Boron Carbide body armor is heavy and limited in the diversity of shapes that may be molded. Its weight and bulk limit a soldier's agility and mobility, and its cost prohibits consideration of using it to protect vehicles. Recent breakthroughs in ceramics processing technology offers the opportunity for cost effective fabrication of molded shapes, the retention of nanostructured grains for significantly higher energy dissipation, a fifty percent reduction in weight for equal ballistic protection, and similar reduction in cost. The focus areas of the program are: the optimization of the material composition and nanostructure for maximum protection per unit weight and cost, and scale up of the fabrication technology to body armor size scale articles. The program will additionally investigate the potential for the development of dramatically improved ballistic armored headgear along these same lines. *FY 2008 Accomplishments:* - Developed lightweight ceramic armor with high dynamic tensile stress to effectively dissipate shock waves. - Investigated backing materials or materials systems for optimized energy dissipation characteristics when used in combination with this new class of ceramics. - Developed improved processing of initial ceramic powder materials for improved ceramic performance, part yield, and yielded cost.		6.114	5.426	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop and model a scalable manufacturing process design for a pilot scale fabrication system capable of producing sufficient high performance ceramic material plates to support the end-manufacture of 1,000 systems per month. - Validate an initial fifteen percent reduction in weight for equal performance compared to currently fielded Enhanced Small Arms Protective Inserts (ESAPI) armor inserts. - Optimize integrated backing materials - ceramic armor materials systems for minimum weight at ESAPI ballistic performance. - Evaluate the characteristics of an optimized LCA system optimized for minimum weight at ESAPI ballistic performance. - Investigate the potential for significantly improved ballistic characteristics of meta-structured ceramic systems incorporating multiple materials layers in a monolithic plate. - Validate a thirty percent reduction in weight for equal performance compared to currently fielded ESAPI armor inserts. - Develop and evaluate initial concepts for ballistic headgear incorporating the LCA materials. *FY 2010 Plans:* - Demonstrate key manufacturing steps at pilot scale throughput with consistent and reliable yielded ceramic part performance.				
Crosshairs (U) The Crosshairs program seeks to develop a vehicle mounted, threat detection, and countermeasure system that will detect, locate, and engage enemy shooters against a variety of threats to include bullets, Rocket Propelled Grenades (RPGs), Anti-Tank Guided Missiles (ATGMs), and direct fired mortars, both stationary and on the move. Threat identification and localization will be accomplished in sufficient time to enable both automatic and man-in-the-loop responses. Phase I of the program focused on initial development and testing of the Crosshairs sensor system. Phase IA culminated with a static live fire test to determine the most effective candidate sensor system. During Phase IB, enhancements were made to the sensor system for on the move performance, and on the move testing against multiple threats was conducted. DARPA and the U.S. Army Rapid Equipping Force (REF) have entered into an MOA for Phase	7.400	17.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
IIA. Phase IIA consists of a moving demonstration of the hardened, packaged, and enhanced Phase I sensor system on two networked HMMWVs (Humvee), integration with candidate response systems, and testing and evaluation of the complete systems in relevant environments. The goal of Phase IIB will be to integrate the final Crosshairs system with an appropriate active protection system (APS). (U) The Concept of Operations is to provide a military vehicle with a mounted detection and response system that operates both stationary and on the move. Bullets will be detected and localized using the acoustic DARPA-developed Boomerang v2.5 acoustic gunfire detection system. Radar detection of all other threats will be made using the Crosscue radar. The Crosscue radar is a dual mode, continuous wave, and pulsed Doppler radar, which will be used to determine range, velocity, and azimuth of the incoming threat. It is envisioned that the system will provide a significantly improved capability to detect and respond to incoming threats during hostile and peacekeeping operations in both urban and non-urban environments. Technology challenges include: low false alarm rate, algorithm development, high speed sensor and data processing for 360 degree azimuth and sixty degree elevation detection zone; robust data collection to locate firing source; and fast response time. The program will culminate with a demonstration of two prototype systems in a typical combat environment. Additionally, the program is investigating the feasibility of a variety of technologies to detect enemy shooters before the firing of a weapon. *FY 2008 Accomplishments:* - Analyzed data and integrated sensors and response system for initial on the move capabilities. - Performed on the move tests with the Vanguard vehicle. - Enhanced on the move sensor system capabilities to include decreasing false alarm and false tracks. - Developed and hardened sensor system. - Identified second overhead weapons station for integration on the Crosshairs vehicle. - Performed on the move testing of the integrated Crosshairs system against a variety of threats. - Integrated overhead weapons station with the Crosshairs vehicle. *FY 2009 Plans:* - Demonstrate the final system capability in live fire tests. - Demonstrate networking capability between two Crosshairs sensor systems.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Begin integration of the APS with the Crosshairs vehicle. - Perform stationary live fire tests of the Crosshairs system integrated with APS. - Demonstrate on the move capability of the integrated system in live fire tests. *FY 2010 Plans:* - Demonstrate the final integrated system capability in live fire tests. - Transition Crosshairs technology to the military.					
Rocket Propelled Grenade (RPG) Nets (U) The goal of the Rocket Propelled Grenade (RPG) Nets program is to develop a near-term counter RPG net system that has performance at least equivalent to bar or slat armor but that is lighter and easier to deploy; and a mid-term net-based system with active elements that has greatly improved performance. Development of these systems will be supported by modeling to enhance understanding of the net interactions and with extensive live fire testing against RPGs. Successful candidates will be installed on vehicles for evaluation in an operational context. *FY 2008 Accomplishments:* - Developed near-term net concepts and performed live fire evaluation. - Began concept development for active net system. *FY 2009 Plans:* - Install near-term net systems on military vehicles and perform initial user evaluation. - Complete user evaluation of near-term net system and transition system. - Complete active net concepts and perform live fire testing. *FY 2010 Plans:* - Begin user evaluation of active net system.		4.722	6.079	3.494	
Small Combat Vehicle with Robotic Automation		0.000	3.000	3.000	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) The Small Combat Vehicle with Robotic Automation program will evaluate and design small, survivable, highly mobile ground combat vehicles that have combat firepower equivalent to today's larger ground vehicles (e.g. M2/M3 Bradley) but in a highly deployable package of five to ten tons with a single crew person/operator on board (with the option for operation with no crew person in an unmanned configuration). Smaller vehicle weights enable effective deployability in helicopters or C-130 aircraft for vertical envelopment. This program seeks to achieve an optimal mix of manned and unmanned technologies in a small, well protected, highly deployable combat vehicle. By utilizing automation technologies in vehicle driving and vehicle payload systems (reconnaissance sensors and weapons), a single crew person in the combat vehicle can effectively drive and operate payloads concurrently at appropriate times while still providing high-level supervisory control over all systems. At mission critical times, the crew person can be removed and supervisory control can be given off-board from a separate controlling vehicle. The key technologies that enable a Small Combat Vehicle with Robotic Operation include sensor-based autonomous and semi-autonomous navigation, robust indirect driving (via combinations of cameras, perception-generated views of the terrain, or teleoperation), robust supervisory semi-autonomous control and teleoperation to allow vehicle operation from another vehicle, high density low-weight armor, aided target acquisition and targeting-based remote weapons stations, effective but minimalist warfighter-machine interfaces for crew person interaction with semi-automated driving and payload systems, and high performance vehicle mobility systems (suspensions and drivetrains). *FY 2009 Plans:* - Conduct initial studies and develop vehicle automation concepts. - Conduct experiments and evaluations of candidate technologies. *FY 2010 Plans:* - Initiate preliminary designs.					
Helicopter ALert and Threat Termination (HALTT) (U) The Helicopter ALert and Threat Termination (HALTT) program will provide Army and Navy/Marine helicopters with a way to detect small arms and Rocket Propelled Grenade (RPG) attacks, improve their ability to respond, and provide affordable defeat of RPGs or other rockets. System effectiveness with		4.050	5.949	6.200	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
emphasis on low false alarm rates is critical. The program goal is to successfully demonstrate protection of helicopters by automatic threat detection of small arms and RPGs, shooter localization, and threat mitigation/defeat. *FY 2008 Accomplishments:* - Conducted component testing of the acoustic system during flight testing. - Completed prototype system level integration with existing aircraft survivability equipment. - Examined rocket threat detection and termination. - Conducted final acoustic component testing and demonstrated the prototype system. *FY 2009 Plans:* - Integrate acoustic prototype system with existing aircraft survivability equipment such as the Common Missile Warning System. - Install prototype HALTT-A(coustic) systems on platforms for training and CONOPS evaluations. - Deploy the HALTT-A prototype system in operational evaluation scenarios. - Develop HALTT system preliminary design and system integration plan. - Begin analysis of defeat mechanisms against RPGs. - Perform live fire testing of individual subsystems. *FY 2010 Plans:* - Provide HALTT-A kits for user evaluation. - Initiate and demonstrate HALTT-R(ocket) detection system. - Demonstrate HALTT-R counter measure.				
C-Sniper (U) Based on promising results obtained under the Crosshairs program, the C-Sniper effort will develop the capability to detect and neutralize enemy snipers before they can engage U.S. Forces. The program will lead to the delivery of a field testable prototype suitable for experimentation as an integrated part of the DARPA Crosshairs system. The C-Sniper system will identify threats before they can fire. The enemy snipers may be operating both with, and without, telescopic sights, and other optical systems in highly	7.945	9.898	6.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
cluttered urban environments. The C-Sniper system will operate day and night from a moving military vehicle and provide the operator with sufficient information to make a timely engagement decision. Once the decision is made, the C-Sniper will provide data and control to point and track the on-board weapon on the selected target. The final decision to fire the weapon will be left to the operator. *FY 2008 Accomplishments:* - Conducted feasibility studies of promising technologies to detect enemy shooters before the firing of a weapon. *FY 2009 Plans:* - Develop the key technologies (laser system, sensor head, and system processing designs). - Develop the interfaces of the sensor system to integrate with Crosshairs. - Conduct systems integration and test on stationary vehicle. - Develop and incorporate system design enhancements required for a moving vehicle. *FY 2010 Plans:* - Develop, deliver and demonstrate the operation of C-Sniper on moving vehicles. - Demonstrate system capability to correctly detect optical systems in highly cluttered urban environment. - Integrate C-Sniper into Crosshairs and demonstrate full system capability. - Commence demonstration of a fully integrated system capable of combining C-Sniper and Crosshairs technologies. - Conduct maritime application feasibility studies to investigate technologies that would enable enemy periscope detection at significant tactical ranges.				
Rocket Propelled Grenade (RPG) Pre-launch Detection and Cueing (U) The Rocket Propelled Grenade (RPG) Pre-launch Detection and Cueing program will enable the development of an omni directional, visual, and vehicle mounted surveillance system for threat detection using cognitive swarm recognition technology to rapidly detect and identify the locations of attackers with RPGs before they are launched. During the first phase of the program, a system will be demonstrated capable of 360 degree coverage and detection rates of greater than ninety five percent. Minimizing	0.000	3.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
false alarms and false positives will be key, as will be true day/night operation and the simultaneous identification of up to five threats. *FY 2009 Plans:* - Develop and mature detection and classification algorithms. - Breadboard test of detection and classification algorithms. - Perform a system demonstration of pre-launch threat detection with stationary cameras. *FY 2010 Plans:* - Perform on-the-move sensor demonstrations of pre-launch threat detection. - Continue to mature detection and classification algorithms. - Integrate technologies for systems application for vehicle mounting and integration. - Interface with existing vehicle sensors to develop a full pre-launch threat detection and cueing capability.					
Counter Improvised Explosives Laboratories (CIEL) (U) Improvised explosives (IEs) are one of the most popular weapons used by terrorist groups. Over the past twenty years, IEs have become very common due to their easy preparation and the high availability of raw materials. Efficient methods for detecting and neutralizing/desensitizing sensitive explosives labs in an urban environment will minimize interference with troop operations and minimize collateral damages. The goal of the Counter Improvised Explosives Laboratories (CIEL) program is to develop the infrastructure and methodology for novel chemo-sensors that would identify labs that are building IEs to a very high degree of specificity and reliability; and develop the infrastructure for tools for safe handling of improvised explosives and their mixtures. The CIEL program will also examine methods to improve current collection methods for detecting sensitive explosives in an urban environment that will minimize interference with troop operations and collateral damages. The goal is to develop efficient techniques for collection of trace explosives that are sufficiently selective and sensitive to be deployed in the field and provide a clear and fast identification of the target explosive.		1.505	1.000	0.585	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Identified a physical method to neutralize/desensitize bulk explosive materials. - Conducted feasibility demonstrations to neutralize/desensitize up to 1 Kg of the pure target explosive and mixtures. - Optimized and demonstrated the sensor on pure target explosives and mixtures. *FY 2009 Plans:* - Develop prototype sensor kit. - Test neutralization/desensitization methods on “field-form” mixtures of explosives. - Design concept of multi-structures “smart” wipe. - Develop methodology of direct spectroscopic analysis of wipe. - Develop prototype of nano-fiber based “smart” wipe. *FY 2010 Plans:* - Demonstration of nanostructure based “smart” wipe. - Develop and field test prototype “smart” wipe.					
Maneuver and Control on the Urban Battlefield (U) This program developed new, high-speed, lightweight, and portable tools including bar cutters, rotary cutters, 5-25 ton spreaders, jamb breakers, deployable personnel barriers, and rooftop access devices. The ultimate program goal was to reduce the weight of existing access tools by eighty percent as well as deliver new and unique capabilities such as direct and rapid rooftop access and rapidly deployed personnel barriers. *FY 2008 Accomplishments:* - Initiated integration of energy storage, power delivery, and end effector components into a single portable lightweight rescue spreader.		2.998	0.000	0.000	
Optical Sensor System		0.800	0.800	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Researched optical sensors. *FY 2009 Plans:* - Select sensor and develop processing for defeat of explosively formed projectiles.				
Novel Sensors for Force Protection (U) The Novel Sensors for Force Protection program explored novel methods that addressed hostile situations to enhance U.S. warfighter protection in the Global War on Terrorism, Operation Enduring Freedom and Operation Iraqi Freedom. *FY 2008 Accomplishments:* - Completed studies to identify the specific regions of the mouse and human genome associated with odorant production in mice and humans.	5.871	0.000	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**
TT-06: ADVANCED TACTICAL TECHNOLOGY	90.867	118.751	88.129						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project focuses on four broad technology areas: a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, communications, and high-power laser applications; b) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; c) enabling technologies for advanced aerospace systems and emerging payload delivery concepts; and d) new approaches for training and mission rehearsal in the tactical/urban environment. Additionally, this project will develop new tactical systems for enhanced air vehicle survivability, precision optics, electronic warfare, and advanced air breathing weapons.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
High Power Efficient and Reliable Laser Bars (HiPER)*	4.000	4.000	0.000	

*Formerly Super High Efficiency Diode Sources (SHEDS).

(U) The goal of the High Power Efficient and Reliable Laser Bars (HiPER) program is to develop linear bars of laser diodes that are more than seventy percent efficient in converting electrical power to optical output power. These laser diode bars will be used for supplying the optical pump power to ytterbium (Yb) and neodymium (Nd) solid state lasers operating near 1060 nanometers (nm). Such high efficiency laser pumps will lead to dramatic reductions in the size and weight of 100 kW class diode pumped solid state lasers based on reduced size and weight of not only the electrical power supply, but also reduced size and weight of the thermal management system. The goal of the HiPER program is also to retain high wall-plug efficiency of over seventy percent while ultimately producing compact laser diode bars with more than 250 W/bar-cm at lifetimes of greater than 100 hours.

FY 2008 Accomplishments:
- Demonstrated laser diode bars operating at seventy-two percent efficiency and at 80 watts per bar.
- Demonstrated an array of vertical-external-cavity surface-emitting laser (VCSEL) laser diodes operating at high-power density and high efficiency.

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Established methods to increase diode power output by increasing laser cavity length without sacrificing efficiency. - Demonstrated improvements in diode lifetime through suppression of filamentation and other laser diode instabilities. - Enabled diode operation at increased inlet water cooling temperatures. - Acquired lasers and established test bed. - Performed laser testing under fault protection to extend diode lifetime. - Performed data reduction and failure mode analysis. *FY 2009 Plans:* - Demonstrate operation of 1cm laser diode bar at a power of 250 watts with a lifetime greater than 100 hours to allow an additional factor-of-2 reduction in diode pumped solid-state laser system size and weight. - Demonstrate novel, compact impingement cooling technology to increase laser diode bar cooling technology and enable 1000 W laser diode bars operating with 1.8mm pitch.					
High Energy Liquid Laser Area Defense System (HELLADS) (U) The goal of the High Energy Liquid Laser Area Defense System (HELLADS) program is to develop a high-energy laser weapon system (150 kW) with an order of magnitude reduction in weight compared to existing laser systems. With a weight goal of <5 kg/kW, HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft and will significantly increase engagement ranges compared to ground-based systems. The HELLADS program has completed the design and demonstration of a revolutionary prototype unit cell laser module that has demonstrated power output and optical wavefront performance that supports the goal of a lightweight and compact 150 kW high energy laser weapon system with near-diffraction limited beam quality. An objective unit cell laser module with integrated power and thermal management is being designed and fabricated by two competing laser suppliers and will demonstrate an output power of >34 kW. Based on the results of the unit cell demonstration, additional laser modules will be fabricated to produce a 150 kW laser that will be demonstrated in a laboratory environment. The 150 kW laser will then be integrated with beam control, power, heat exchange, safety, and command and control subsystems that are based upon existing technologies to produce a laser		32.665	40.608	35.388	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
weapon system demonstrator. The capability to shoot down tactical targets such as surface-to-air missiles and rockets and the capability to perform ultra-precise offensive engagements will be demonstrated in a realistic ground test environment. The HELLADS laser will then be transitioned to the Air Force for aircraft integration and flight testing. *FY 2008 Accomplishments:* - Fabricated a test head and characterized the optical performance of the test head. - Initiated development of a second approach for a HELLADS unit cell laser module that meets all performance requirements. - Completed preliminary design of a 150 kW laser weapon system demonstrator. *FY 2009 Plans:* - Fabricated a prototype unit cell and characterized power output and optical wavefront of the prototype unit cell. - Complete a unit cell laser module with integrated power and thermal management subsystems and demonstrate power, beam quality, run-time, weight, and volume. - Complete detailed design of a 150 kW laser weapon system demonstrator. - Initiate field testing of individual laser weapon system components. - Perform static lethality testing against targets to be utilized in the field demonstration of the 150 kW laser weapon system. *FY 2010 Plans:* - Initiate fabrication of additional unit cell laser modules to complete the 150 kW laser. - Complete the fabrication and laboratory testing of the 150 kW laser. - Complete fabrication of the demonstrator laser weapon system. - Complete demonstrator laser weapon system component and subsystem testing. - Initiate integration of the 150 kW laser with the laser weapon system.					
Aero-Adaptive/Aero-Optic Beam Control (ABC)		4.000	5.000	4.890	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The goal of the Aero-Adaptive/Aero-Optic Beam Control (ABC) program is to improve the performance of high energy lasers on tactical aircraft against targets in the aft field of regard. In order to achieve high off-boresight targeting capability, current optical turret designs protrude into the flow. This causes severe aero-optic distortions in the aft field of regard due to turbulence in the wake and the unsteady shock movement over the aperture. These distortions decrease the power flux on target (the measure of lethality for a directed energy system) and consequently limit the directed energy system to targets in the forward field of regard. This program will optimize flow control strategies for pointing angles in the aft field of regard. The program will also explore the ability of the flow control system to be synchronized with adaptive optics. This effort will initially focus on wind tunnel testing to prove the feasibility of steady and periodic flow control techniques to reduce or regularize the large scale turbulent structures surrounding an optical turret. These tests will now culminate in a hardware-in-the-loop demonstration utilizing flow control with an adaptive optics system in a full-scale wind tunnel test for the turret. Following successful wind tunnel demonstrations, a preliminary design of a flight test turret incorporating flow control will be undertaken. *FY 2008 Accomplishments:* - Initiated trade studies and computational fluid dynamics (CFD) analyses. - Characterized turret aero-optical performance with CFD analysis and small-scale wind tunnel testing. - Downselected to preferred turret configuration. *FY 2009 Plans:* - Use CFD analyses to optimize blowing slot configuration. - Assess wavefront measurements for a range of pointing angles. - Downselect flow control actuation technique. - Model effects of adaptive optics on system performance. - Assess military utility of system improvements achievable with flow control and adaptive optics. *FY 2010 Plans:* - Design and fabricate ABC optics for full scale wind tunnel test of turret. - Design and fabricate ABC flow control actuators for full scale wind tunnel test.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Perform bench-level evaluation of system functionality using phase screens.				
High Performance Algorithm Development	12.931	5.200	5.000	
(U) The High Performance Algorithm Development programs identify, develop and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a variety of DoD systems applications. The programs look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit large-scale computational resources as they apply to specific problems of interest. They also cultivate theoretical breakthroughs in areas of basic mathematics having relevance to emerging defense sciences and technologies. The products are typically advanced algorithms and design methodologies. DARPA is pursuing the development of well-conditioned fast algorithms and strategies for the exploitation of high-dimensional data (i.e., data with a high number of degrees of freedom) in order to deal with a variety of complex military problems including digital representation and analysis of terrain and other geospatial data, efficient high fidelity scattering computations of radar scattering for predictive design and exploitation of radar cross sections, and efficient automatic mapping and optimization of signal processing kernels onto advanced departmental computational hardware architectures. After a review of program goals and content, two efforts funded under this program, 23 Mathematical Challenges and Focus Areas in Theoretical Mathematics, were reclassified as basic research and moved to PE 0601101E, Project CCS-02 beginning in FY 2009.				
FY 2008 Accomplishments: - Extended methods from kernels to end-to-end applications including JPEG2000, Viterbi coding, and Synthetic Aperture Radar (SAR) processing. - Extended time reversal theory to form complete images of targets in multipath environments. - Tested hypothesis that multipath scattering will enable portions of the target that are not illuminated to be imaged. - Developed test range facility and clutter environment to support experimentation at Ka band. - Extended methods to cope with nonlinear systems with dimensionality greater than 10,000 degrees of freedom. - Accelerated the methods to achieve 100 times performance over particle filtering and Monte Carlo sampling.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

- Demonstrated the method in 2.5 dimensions with over 10,000 degrees of freedom.
- Developed novel clustering algorithms that address stochasticity and uncertainty.
- Expanded software tool capability and functionality to address complex datasets of military importance.
- Injected novel mathematical tools into quantum physics calculations.
- Developed new mathematical approaches to approximate infinite calculations by polynomial ones.
- Demonstrated new mathematical results in large scale computation based on novel multi-parameter filtering methods.
- Developed new mathematical results in rigid geometry based on novel algorithms.
- Demonstrated new mathematical results in expander graph technology for potential applications to materials science.

FY 2009 Plans:

- Develop a quantitative methodology in the area of information propagation, impact and persistence for the military and coalition environment relying on observations from neuroscience, cognitive science and social networking.
- Identify the signatures of information/target message endurance among disparate groups and cultures through measures of neuroscience and behavior.
- Demonstrate that by using the Discovery and Exploitation of Structure in Algorithms (DESA) tools non-expert users can design end-to-end systems in 1/10th the time of expert designers.
- Extend DESA tool suite to other common signal processing and image formation algorithms.
- Extend time reversal methods to acoustic channels and increase the computational speed of the Green's function by 100.
- Use topological tools to analyze higher-order datasets in biology, sensing, and neuroscience.
- Develop geometric theory of higher dimensional clustering for novel data analysis.

FY 2010 Plans:

- Develop the neural signatures for key variables in information propagation and persistence in the brain specifically related to military and coalition operations.
- Develop brain imaging methodologies and tasks to specifically measure altruism, persuasion, and trust in individuals, dyads and groups.

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Develop a comprehensive and quantitative theory of information movement and persistence among individuals and groups to better predict and control responses to specific messages and events. - Develop and use novel topological tools to analyze non-linear dynamical systems. - Implement geometric theory of higher dimensional clustering for novel data analysis to produce user-friendly fast algorithms. - Develop multi-parameter and multi-dimensional topological persistence algorithms to extract high dimensional, dynamic, hidden features in massive data sets across DoD applications; including communications, biology, neuroscience as well as classically important radar and other digitally represented applications. - Develop a new family of non-increasing stochastic processes that enables the replacement of propensity by probability in uncertainty modeling. - Develop an Ito-style stochastic calculus to build theoretical models to improve uncertainty prediction.					
Integrated Sensing and Processing (U) The Integrated Sensing and Processing program will open a new paradigm for application of mathematics to the design and operation of sensor/exploitation systems and networks of such systems by developing and applying novel optimization methodologies for integrating sensing, processing, and information exploitation functionality in sensor systems. This program will create tools enabling the design and global optimization of advanced sensor system architectures comprising fully interdependent networks of functional elements, each of which can fill the roles and functions of several distinct subsystems in current generation sensor systems. Payoffs will include improved performance with reduced complexity of hardware and software in a wide variety of systems, including agile adaptive arrays for missile seekers, unmanned air vehicles, and space-borne sensors; novel waveforms, and novel approaches to multiplexed hyper-spectral chemical/biochemical sensing systems. *FY 2008 Accomplishments:* - Established topological methods for deterministic target enumeration. - Established novel algorithms to guarantee capture in pursuit and evasion scenarios in non-convex domains.		4.373	7.500	6.400	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Developed new algorithms for reaching consensus among independent agents in motion planning and resource allocation. - Extended the registration methods for two-dimensional (2-D) (electro-optical and video) data and three-dimensional (3-D) laser imaging detection and ranging (LIDAR) data from complex urban environments. - Extended the elevation data compression methods for three-dimensional LIDAR point clouds for evaluation in path planning applications. *FY 2009 Plans:* - Transition compression technology to National Geospatial Agency commercial geospatial products. - Extend deterministic theory to cover spaces for network systems and sensing applications. *FY 2010 Plans:* - Extend graph topology to simplex methods to develop novel algorithms in strategy complexes and Bayesian decision trees. - Generate algorithms to provide flexible, movable, reactive border generation for dynamics and unpredictable events.					
Training Superiority (U) The Training Superiority program will change the paradigm for military training by creating new approaches to increase technical competence. Passive teaching approaches, including web-based training, will not succeed in instilling the skills and knowledge needed in the new land-battlefield, with higher demands on fewer soldiers, including the need to control and interact with highly technical unmanned systems. These new training approaches will include elements of human-tutor interactions and the emotional involvement of computer games coupled with the fidelity and feedback of Combat Training Center learning. In addition, this thrust will scale-up new digital tutor methodologies, deliver these to a large cohort of warfighters, and demonstrate a convincing benefit compared to standard training in an operational environment.		8.791	13.071	8.900	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Created compelling, digital tutor training for Navy information technicians that trains as well as the best human tutors. - Designed experiment and developed metrics to demonstrate and validate the effectiveness of Digital Tutor training in schoolhouse setting. - Began knowledge elicitation efforts for building full scale Digital Tutor. *FY 2009 Plans:* - Demonstrate forty hour Digital Tutor, teaching one week of content, in a production software configuration. - Port three weeks of content from a human-tutored course to the Digital Tutor and test in a laboratory setting. - Validate knowledge elicitation data for full scale Digital Tutor in a leading Information Technology (IT) school setting. - Conduct and evaluate the first Information Warfare Cup (IWARS Cup) using the human-tutored team to provide real-world validation of Digital Tutor training methodology. *FY 2010 Plans:* - Port two months of Navy IT-School content from a human-tutored course to the Digital Tutor. - Elaborate intrinsic, instrumental and extrinsic motivation models in order to maintain student motivation over two months of instruction demonstrated over one week. - Create an automatic capability to identify students requiring remediation.				
RealWorld (U) The RealWorld program exploits technical innovation and integration to provide any U.S. warfighter with the ability to open a laptop computer and rehearse a specific mission in the relevant geo-specific terrain, with realistic physics. Because the system will be scalable and distributed, warfighters can practice by themselves, in small groups, or with as many other warfighters as needed for the mission over a local or distributed network, and across all relevant platforms (dismounts, vehicles, helicopters, and fast movers). Most important is the understanding that RealWorld is not a static simulation; it is a simulation builder	7.200	12.125	7.494	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

with applications across the spectrum of modern kinetic and non-kinetic warfare. The program is building tools that allow warfighters to rapidly and easily build their own missions though the introduction of new methodology for building simulation software. These methodologies and adherence to a highly modular approach will cause a fundamental paradigm shift in the acquisition, as well as the construction, of DoD modeling and simulation products.

FY 2008 Accomplishments:

- Demonstrated automated geo-specific terrain from digital terrain elevation data.
- Demonstrated scalability to 250 live network participants running on a single server, thus surpassing current DoD multi-player capacity.
- Demonstrated integration of Newtonian physics.
- Applied RealWorld simulation builder to digital cockpit training.
- Transitioned RealWorld Air component to Air Force as the universal trainer for A-10C.
- Applied RealWorld simulation builder to electronic warfare applications.
- Transitioned RealWorld Electronic Weapons Officer component to Air Force.
- Scaled to 500 entities.
- Demonstrated three-dimensional (3-D) positional audio, multi-channel audio and physical modeling of communications jamming effects including multi-spectrum and frequency jamming.
- Implemented an artificial intelligence (AI) Abstraction layer allowing the future integration of disparate AI systems.
- Ingested 1 sq. km. of government terrain data into a physics based 3-D real-time software environment in thirty minutes.
- Ingested 360 sq. km. of government terrain data into a physics based 3-D real-time software environment in four hours.
- Created up to 38,000 sq. km of terrain data for air specific missions, anywhere in the world, in one hour.
- Automatically generated the interior (including furniture and stairways) and exterior of a geo-typical building of any size or footprint in under five minutes that includes building material types by zip code.
- Initiated development of a universal medic simulation builder.
- Demonstrated utility as a trainer for at least one Special Operations Command (SOCOM) application.

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Demonstrate dynamic path finding such that entities will be able to maneuver in a terrain deformed geo-specific area. - Integrate a full Newtonian physics modeling engine in a real-time 3-D engine in both a hardware enhanced and software only modality. - Transform a laser imaging detection and ranging (LIDAR) data collection set into a 3-D model (using topology graph analysis and parametric model fitting) capable of being utilized by a real-time 3-D engine. - Ingest up to one square mile of LIDAR terrain data and render 3-D models in less than one hour. *FY 2010 Plans:* - Scale to 1000 entities. - Integrate meteorological capability so real-time weather can be imported into training and rehearsal scenarios. - Demonstrate integration of data from Google Earth. - Transform pictures taken by a cell phone camera into a 3-D model capable of being ingested by a real-time 3-D engine with an accuracy of one or less.					
Discharge Excited Catalytic Oxygen Iodine Laser (DECOIL)* *Formerly Air Laser. (U) The objective of the Discharge Excited Catalytic Oxygen Iodine Laser (DECOIL) program is to investigate the potential of the electric oxygen iodine lasers to make maximum use of air (80%N2/20%O2) in the laser device. The DECOIL device is an alternative to the well known chemical oxygen iodine laser (COIL) developed in 1977 and scaled to megawatt (MW) levels. DECOIL offers the potential of an open or closed cycle, electrically powered system with minimal stored consumables, no toxic, complex, and massive chemical storage and handling, and all the advantages of COIL such as excellent beam quality, operation in an atmospheric window, and high power operation. The goals of the DECOIL program are to demonstrate 1 kilowatt laser output, and develop a preliminary design for a 150 kilowatt laser system.		1.000	2.000	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed and demonstrated a 1 kW output power laser design. *FY 2009 Plans:* - Demonstrate laser outcoupled power of = 100 Watts. - Demonstrate beam quality (M2) of = 1.2. - Demonstrate wallplug electrical efficiency of = 10 percent.				
Efficient Mid-Wave Infrared Lasers (EMIL) (U) The Efficient Mid-Wave Infrared Lasers (EMIL) program will develop efficient solid-state coherent sources to cover the atmospheric transmission bands in the mid-wave infrared (MWIR; 3-5 micrometers). Infrared countermeasure (IRCM) systems in particular depend on intense sources at these bands. The current generation IRCM systems utilize diode-pumped Thulium (Tm) lasers used to pump optical parametric oscillators, most commonly based on zinc germanium phosphide. (U) The lasers developed in this program will operate across the three relevant bands within the MWIR at 10 W power with wall plug efficiencies of at least 10 percent. By virtue of the enormous volumetric reduction (100-1000 times), power reduction (ten times), and superior pulse format (cw-operation), such sources will enable new architectures and approaches permitting IRCM systems to be deployed on platforms (e.g., rotocraft) which are highly vulnerable to Man Portable Air Defense Systems and other threats but for which current IRCM systems are prohibitive or are inadequate (e.g., unable to defeat staring sensors). At least two diode-based laser approaches will be explored in this program, both involving antimonide-based compound semiconductor materials. These include intersubband-based quantum cascade lasers (QCLs) and type-II antimonide lasers, including so-called “W-configuration” approaches, the name taken from the shape of the conduction band profile. *FY 2008 Accomplishments:* - Demonstrated the projected efficiency, power and beam quality levels from single-mode Indium Phosphide (InP)-based QCL emitters. - Demonstrated device mounting modeling and fabrication for reduced electrical and thermal resistance.	5.700	7.900	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Tested final device integration. *FY 2009 Plans:* - Scale the power, in a parallel development, of the efficient individual QCL sources developed previously. *FY 2010 Plans:* - Demonstrate epitaxial growth and preliminary characterization of final structures.				
Sonic Projector (U) The goal of the Sonic Projector program is to provide the services with a method of surreptitious audio communication at distances over 1 km. Sonic Projector technology is based on the non-linear interaction of sound in air translating an ultrasonic signal into audible sound. The Sonic Projector will be designed to be a man-deployable system, using hardware and signal processing algorithms which result in clear audible signals at the desired location and unintelligible sound at locations away from the desired location. The Sonic Projector system could be used to conceal communications for special operations forces and hostage rescue missions, and to disrupt enemy activities. *FY 2008 Accomplishments:* - Conducted analysis for high-power ultrasonic transducers, and precision beam control and focus for location tracking. *FY 2009 Plans:* - Develop transducer array design for far-field propagation. - Evaluate concept of operations.	2.437	1.000	0.000	
Revolution in Fiber Lasers (RIFL) (U) The goal of the Revolution in Fiber Lasers (RIFL) program is to develop multi-kilowatt, single-mode, narrow line fiber laser amplifiers using efficient, high brightness laser diode pump arrays. These narrowline fiber laser amplifiers can then be coherently combined to develop ultra-high power electronically	3.552	11.330	10.551	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
steerable optical phased arrays. In Phase 1 of this program, a 1 kW narrowline, single mode, single polarization fiber laser amplifier will be developed with 15% electrical efficiency and a beam quality of better than 1.4x diffraction limited. In Phase 2 of this program, a 3 kW narrowline, single mode, single polarization fiber laser amplifier will be developed with 30% overall electrical efficiency and better than 1.4x diffraction limited beam quality. Coherent arrays of these high power fiber laser amplifiers will then be developed as part of the DARPA Adaptive Photonic Phase-Locked Elements (APPLE) program (PE 0603739E, Project MT-15) to achieve the requisite power and coherence for future multi-kilowatt high power laser weapons. *FY 2008 Accomplishments:* - Performed final engineering designs of a 1 kW coherently combinable fiber amplifier (single mode, single polarization, narrow line) that will support development of a high power fiber laser optical phased array and that will provide >15% electrical efficiency and near-diffraction-limited beam quality (M2 < 1.4). *FY 2009 Plans:* - Initiate construction of 1 kW coherently combinable fiber amplifiers (single mode, single polarization, narrow line) that will support development of a high power fiber laser optical phased array and that will provide >15% electrical efficiency and near-diffraction-limited beam quality (M2 < 1.4). - Complete final engineering design of a 3kW, 30% efficient, near-diffraction-limited coherently combinable fiber laser amplifier (single mode, single polarization, narrow line) that will support development of high power fiber laser optical phased arrays for laser weapon applications. *FY 2010 Plans:* - Demonstrate and test 15% efficient, single mode, single polarization, coherently combinable fiber laser amplifiers with near diffraction-limited beam quality at 1kW power level.					
Coherently Combined High-Power Single-Mode Emitters (COCHISE) (U) The Coherently Combined High-Power Single-Mode Emitters (COCHISE) program will develop four new, breakthrough technologies that will result in improved diode bar lifetime and beam quality. Ultimately, these technologies will also lead to coherent combination of individual emitters in laser diode bars and		2.300	5.017	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
arrays. Coherent combination of laser diode arrays would provide high power laser architectures that are up to three times more efficient than existing diode-pumped solid-state laser technology, while improving beam quality and increasing far-field, on-axis intensity. *FY 2008 Accomplishments:* - Demonstrated a diode bar pre-screening technology based on spectral measurements made on each emitter that can detect <1 degree Celsius temperature changes among these emitters simultaneously and that can detect packaging defects and other manufacturing defects (High Energy Liquid Laser Area Defense System (HELLADS) diode bars). - Correlated electrical fault mode detection based on voltage drops at the diode terminals with optical fault mode detection based on spectral splitting in diode or bar emission (>seventy percent correlation). - Demonstrated that fault mode frequency as detected electrically at the diode bar terminals correlates with diode bar lifetime – use as an additional diode bar pre-screening technology. - Demonstrated that SHEDS/HiPER laser diode bar lifetimes can be extended beyond 500 hrs at full efficiency and power with fault mode protection. - Demonstrated phase control of individual slab-coupled optical waveguide lasers (SCOWL) emitters to >0.1 waves with a compact diode driver containing integrated fault-mode, protection and the ability to cut current to the SCOWL diode in <2 microseconds. *FY 2009 Plans:* - Demonstrate coherent combination of a bar of single mode SCOWL diodes at 10 W with 1.4x diffraction limited beam quality. - Develop electrical power supply, microscale power distribution, and holographic optical elements to support coherent combination of 10 bars of SCOWL laser diodes with each bar operating at a power level of 10 watts. *FY 2010 Plans:* - Demonstrate coherent combination of 10 bars of single mode SCOWL laser diodes at a total power of 100 W with better than 1.4x diffraction limited beam quality and at better than 30% electrical efficiency.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Demonstrate coherent combination of 30 bars of single mode SCOWL laser diodes at a total power of 1000 W with better than 1.4x diffraction limited beam quality at better than 40% efficiency.				
Architecture for Diode High Energy Laser Systems (ADHELS) (U) The Architecture for Diode High Energy Laser Systems (ADHELS) program is developing technology to allow scaling of spectral beam combining of high power fiber laser amplifiers to power levels greater than 100 kW. Such high power laser systems would result in overall electrical efficiencies exceeding 30% with near-diffraction-limited beam quality and electric laser systems that are more than ten times lighter weight and more compact than existing chemical laser systems. *FY 2008 Accomplishments:* - Demonstrated a moderate-power spectrally combined fiber laser with high-efficiency and good beam quality. - Demonstrated a surface-emitting distributed feedback (SE-DFB) laser diode operating at high-power, high-efficiency and good beam quality. - Demonstrated volume Bragg gratings suitable for high-power beam combining and good spectral efficiency. - Demonstrated a moderate-power laser with record-high efficiency and excellent beam quality. - Demonstrated a SE-DFB laser diode operating at high-power, record-high efficiency and excellent beam quality. - Demonstrated volume Bragg gratings suitable for high-power beam combining and high-spectral efficiency. *FY 2009 Plans:* - Design a 700 W, ultra-high spectral density, spectrally combined fiber laser amplifier system using efficient, diffraction-limited, volume Bragg gratings. *FY 2010 Plans:* - Construct and test a 700 W, ultra-high spectral density, spectrally combined fiber laser amplifier system using efficient, diffraction-limited volume Bragg gratings.	1.918	1.000	0.506	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
GORGON - High Power Mid-IR Laser	0.000	3.000	4.000	

(U) GORGON, a High Power Mid-IR laser program, will develop advanced laser technologies to provide infrared counter measures (IRCM) capabilities for a variety of airborne platforms in conjunction with the Multi-function Electro-optical Defense of U.S. Aircraft (MEDUSA) program. Defense of aircraft against incoming IR guided missiles, especially man-portable air-defense systems, represents a crucial capability with vital applications in both the military and commercial sectors.

(U) Two technologies will be developed in this program. The first technology is based on a Thulium: yttrium lithium fluoride (YLF) thin slab lasers operated in a zigzag configuration to preserve beam quality at high average power. This laser offers the ability to store the energy invested in population inversion for up to 500 microseconds so that efficient, Q-switched formation of short pulses is possible. In addition, this laser system can provide the required 100 nanometer tunability as well as efficient operation with available ultra-high efficiency pump diodes. This concept offers near-diffraction limited beam quality and output power scalable to levels ultimately required for negation of IR detectors at long range.

(U) The second technology is a laser based on double-clad erbium (Er)-doped zirconium barium lanthanide sodium fluoride (ZBLAN) fiber pumped with 975 nanometer wavelength laser diode bars. Using 4 meter long fiber, researchers have demonstrated 9 Watts of continuous-wave output at 3 micrometers. To achieve this power increase, the natural population-inversion bottleneck caused by the longer lifetime of the lower laser level relative to the upper laser level for the Er atoms was overcome by using a heavily Er-doped ZBLAN double-clad fiber. A technique called energy-transfer upconversion was used, in which an energy-transfer process between Er ions solves the population bottleneck and increases the output power. The laser was pumped with 43 Watts of optical power and its slope efficiency was over twenty-one percent. The infrared output was limited by optical damage of the pumping end facet. The challenge is to produce ZBLAN fibers capable of withstanding higher optical fluxes and longer wavelength emission.

FY 2009 Plans:
- Demonstrate 10 Watts average power.
- Demonstrate 30 nanometer tunability.
- Demonstrate beam quality better than 5x diffraction limited.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Demonstrate 25 Watts average power. - Demonstrate 75 nanometer tunability. - Demonstrate beam quality better than 3x diffraction limited.				

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**
TT-07: AERONAUTICS TECHNOLOGY	37.067	48.201	50.066						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) Aeronautics Technology efforts will address high payoff opportunities that dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. This includes advanced technology studies of revolutionary propulsion and vehicle concepts, sophisticated fabrication methods, and examination of novel materials for aeronautic system applications.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Helicopter Quieting	9.900	6.000	3.800	
(U) Studies and analysis of military helicopter operations have shown that the survivability and lethality of U.S. helicopters can be increased by reducing the range at which their acoustic signature can be detected and recognized. The goal of the Helicopter Quieting program is to advance the capability to analytically develop advanced rotor technologies that can dramatically improve the survivability of military rotor systems, while enabling improvements to performance, affordability, availability and suitability. A critical element toward this goal is to create and demonstrate a physics-based design toolset that enables analytical design of novel rotor systems and rotorcraft for reduced acoustic susceptibility (detection and recognition) by human and electro-acoustic threats. (U) Current rotor development is very costly, involving a time-consuming iterative, trial and error cycle of analysis and model wind tunnel tests, or occasionally, a faster but much riskier analysis path directly to full-scale wind tunnel/flight test. Additionally, the primary limitation of existing computational models is their inability to accurately predict the pressure distribution on a rotor blade and in the flowfield away from the blade. Novel and creative concepts and ideas are being employed in this program for accurate aerodynamic analysis of helicopter rotor airloading, flowfield, and wakes using high-end computational fluid dynamics techniques. The program will develop tools capable of accurate prediction of the noise signature of advanced, rotor concepts that exhibit a significant reduction in low-frequency in-plane signatures.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) This program will also undertake the development of propagation and perception modeling for rotorcraft acoustic signatures within state-of-the-art visualization architectures. Multiple advanced human perception and cueing models will be developed as a part of the integrated acoustic design and analysis environment. The ability of the toolset to accurately characterize the differences in these factors will support design decisions for advanced rotors and rotorcraft that exhibit dramatically reduced perceptibility. The toolset will also enable assessment of operational tactics, techniques, and procedures, to include pilot technique, toward optimization for survivability. *FY 2008 Accomplishments:* - Validated and applied high-fidelity, physics-based rotor acoustic predictive tools for rotors that exhibit complex aerodynamic phenomena atypical of conventional, fielded rotorcraft. *FY 2009 Plans:* - Deploy near real-time mission planning and visualization tool set capturing and displaying the rotorcraft's acoustic probability of detection. - Complete and deliver Beta test software for supersonic show-of-force missions. *FY 2010 Plans:* - Identify acoustic design criteria for new rotor system designs based on operational scenarios. - Integrate high-fidelity rotor acoustic signature prediction, physics-based propagation modeling and advanced human perception models. - Develop capability to dramatically enhance reduced perception and supersonic show-of-force missions. - Analytically demonstrate dramatic survivability improvement through reduced acoustic signature (Sonic Evasion). - Demonstrate dramatic improvement to supersonic show-of-force missions.				
Nano-Flapping Air Vehicles (U) The goal of this program is to develop a flapping and rotary air vehicle technology that results in a bio-inspired flapping and rotary air vehicle with less than a two inch wingspan and gross take-off weight of approximately ten grams or less. Operations in the urban terrain require sensors that can navigate	9.726	5.000	2.500	

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B. Accomplishments/Planned Program ($ in Millions)		FY 2008	FY 2009	FY 2010	FY 2011
in difficult terrain and be inserted without being detected. Small air vehicles capable of navigating interior domains without GPS would enable autonomous prosecution of a number of high risk missions that are currently performed by warfighters. Key enabling technologies include: flapping and rotary wing aerodynamics, kinematics and flight dynamics, lightweight aeroelastically tailored wing structures, miniature navigation systems, micro-propulsion systems, small payloads, and the ability to perch like a bird. This effort will also examine novel materials that can be used to develop integrated wing structures, which change composition to achieve multiple expressions. The program would result in the use of vehicles, which could be camouflaged, or blend into the surrounding landscape, enabling in-theater disposal and prevention of mission detection/compromise. *FY 2008 Accomplishments:* - Demonstrated robust flapping and rotary mechanisms that produce 10 grams of lift, integrated wing design with air vehicle, and demonstrated reliable flapping/rotary wing manufacturing principles. - Demonstrated image-aided navigation allowing the nano air vehicle to maintain station in an indoor environment by automatically tracking the position of features within video. - Demonstrated low-power, low-mass, high-deflection piezoelectric tilt-actuation of 7.5 cm rotating wing. *FY 2009 Plans:* - Demonstrate roll-pitch-yaw control of a flapping air vehicle using only wind-stroke modulation, modeled after birds and insects. - Demonstrate sustained hover of a flapping air vehicle. - Develop preliminary design of a flapping or rotary wing nano air vehicle and control system to assist platoon/squad level operation in urban and indoor environments. - Demonstrate on-board, autonomous image-aided navigation and collision avoidance. *FY 2010 Plans:* - Integrate light weight, low-power, low-light cameras to support nighttime urban operations. - Demonstrate prototype vehicle in urban combat missions.					
Battlefield Helicopter Emulator (BHE)		8.750	8.321	7.766	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) The goal of the Battlefield Helicopter Emulator (BHE) is to develop a system capable of emulating rotorcraft signatures, compatible with installation as a payload on a small UAV. The system will provide helicopter signature emulation of a variety of battlefield helicopters. BHE could be used for mine clearing/ route determination as well as escort missions. An operational system could draw fire from ground based adversaries, and relay the information back to the operator for off-board location and prosecution. The system offers the opportunity to protect a large number of military aircraft assets and crews over long periods without aircraft performance impact. The reduced acoustic perception distance enabled by the BHE system can reduce the risk to Army and Special Operations Command helicopters from ground fire, small arms, rocket-propelled grenades (RPGs), man-portable air defense systems (MANPADS), and anti-helicopter mines (AHMs). *FY 2008 Accomplishments:* - Identified technical approaches for adequately emulating critical signatures. - Characterized signatures of battlefield helicopters. - Developed concepts to emulate battlefield helicopter signatures. - Developed and tested emulator system to demonstrate technological feasibility in a laboratory environment. - Developed an analytical constructive simulation capability to assess performance of proposed technologies and mature key system performance criteria. *FY 2009 Plans:* - Demonstrate numerous emulator systems in multiple signature bands in a field test. - Select emulator systems for integration with UAV platform. *FY 2010 Plans:* - Integrate emulator systems onto tactical unmanned aircraft systems. - Conduct first flight, envelope expansion and performance characterization.					
Distributed Embedded Propulsion		0.000	1.743	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Distributed Embedded Propulsion program explored using fully integrated engine/wing designs to take maximum advantage of a fully coupled engine/wing system. The concept involved utilizing multiple small engines to provide the thrust for the aircraft, and to allow the engines to be more readily integrated with the aircraft structure and the aerodynamics of the wing. *FY 2009 Plans:* - Conducted trade studies on aircraft sizing for short field take-off and landing and to determine the benefits of alternative propulsion systems in a distributed propulsion system. - Evaluated conceptual designs of distributed embedded propulsion concepts and assess aerodynamic performance.				
Drag Reduction Flight Demonstration* *Formerly Laminar Flow Flight Demonstration. (U) The Drag Reduction Flight Demonstration effort will explore the development of an extended laminar flow wing, with the potential for a drag reduction of up to twenty-five percent compared to a typical fully turbulent wing, and the development of a formation flight capability, with drag reduction up to seventeen percent compared to solo flight aircraft. In addition, this program will evaluate and demonstrate the ability for autonomous aircraft to compensate for arbitrary loss of flight control, e.g. due to battle damage. Crossflow instabilities dominate the transition process for swept wings. Recent advances in theoretical understanding of the crossflow receptivity and transition process have led to innovative, passive control concepts for the crossflow transition process. Test facilities are not available to demonstrate this flight concept in a quiet flow environment at flight-representative Reynolds numbers and Mach numbers. Flight testing a swept wing laminar flow control concept appears to be the most direct route to validation of this technology, enabling future aircraft designs to adopt passive crossflow control devices as a proven technology. Formation flight is used in nature by geese and other migratory birds to reduce drag, but requires the development of an autonomous system to maintain the optimum position for drag reduction to be practical for long duration aircraft flights. Flight testing a formation flight configuration will allow structural excitation, and vehicle dynamic response to be addressed in proximity to the lead aircraft wake.	2.000	4.300	7.000	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Evaluated design constraints for laminar flow wings. - Tested limits of damage tolerant control approach, including an initial implementation of automatic supervisory adaptive control. - Assessed potential aerodynamic benefit of 2 and 3 aircraft formations. *FY 2009 Plans:* - Conduct feasibility study of high Reynolds number flight test. - Conduct integration of damage tolerant controls across a range of flight conditions, including attitude control, upset recovery, redundancy management, and dynamic flight envelope restriction. - Assess legacy data from wake crossing studies to determine impacts on flight control systems. *FY 2010 Plans:* - Initiate design of flight test experiment. - Initiate design of laminar flow wing for demonstration. - Collect flight test data to assess autopilot faults, alarms, and structural response of the aircraft wing in proximity to the aircraft wake.					
Disc-Rotor Compound Helicopter (U) The goal of the Disc-Rotor Compound Helicopter program is to design and demonstrate the enabling technologies required to develop a new type of compound helicopter capable of high-efficiency hover, high-speed flight, and seamless transition between these flight states. The aircraft will be equipped with an aft-swept wing, as well as a mid-fuselage disc with extendable rotor blades, enabling the aircraft to take-off and land like a helicopter. Transition from helicopter flight to airplane flight would be achieved by fully retracting the blades within the disc. An aircraft capable of long range high speed (300-400 kts) and Vertical Take-off and Landing (VTOL)/hover will provide mobility and responsiveness for troop and cargo insertion, satisfy an ongoing military interest for higher speed VTOL and hover capable vehicles, be survivable and bridge the gap in helicopter escort and insertion missions. The enabling technologies are disc-rotor configuration, variable thrust ducted prop-fans, the extension of the telescoping blades and seamless reversible transition between hover and wing borne flight. Specific objectives of the Disc-Rotor		3.000	0.000	0.000	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Compound Helicopter program include: demonstrating the feasibility of retracting the extendable blades into the disc, characterizing the flowfield environment created by a disc-rotor, demonstrating disc-rotor enabling technologies, and design and flight testing a demonstrator. Beginning in FY 2009, this program will budgeted in PE 0603286E, Project AIR-01. *FY 2008 Accomplishments:* - Developed a conceptual design and established performance metrics. - Identified the critical enabling technologies required to meet the performance goals.					
Integrated Compact Engine Flow Path (U) The goal of the Integrated Compact Engine Flow Path program is to fully integrate the aircraft structure and propulsion flowpath. This will include development of a structurally integrated, load bearing, composite, thrust vectoring nozzle. Integration of compact inlets and nozzles that are lightweight and survivable continue to be a challenge in military aircraft design. Multiple distributed inlets and nozzles may allow a better integrated wing and propulsion system, exploiting aerodynamic control possible with engine blowing and suction. Existing metal nozzles are cantilevered off the engine face and the airframe, with an overlap region to allow for thermal growth. This approach to nozzle integration results in heavy, high maintenance nozzles and is structurally inefficient. It also poses a significant engine integration challenge and can drive vehicle sizing. A fully integrated nozzle, designed to take airframe loads through the nozzle, and built of a high temperature ceramic, would address the weight and structural integration problems directly. This approach would also be compatible with fluidic thrust vectoring and would result in a more compact, lighter, and more durable nozzle. This program will design, develop, and demonstrate a full scale, integrated engine flowpath in a direct-connect engine test. *FY 2009 Plans:* - Perform combined temperature and pressure testing of a representative full-scale nozzle throat section. - Confirm predictive capability of combined thermal and pressure loading structural strains. - Initiate design trade studies to develop a preferred nozzle design as well as a development and demonstration plan.		0.000	4.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Perform design studies for a dynamic loads test nozzle. - Perform detailed design of a ceramic matrix composite nozzle to be built of high temperature ceramics. - Assess benefits of an integrated engine flowpath on the aircraft performance.					
Active Rotor (U) The goal of the Active Rotor program is to develop and demonstrate enabling technologies that greatly enhance rotor control and performance, availability, sustainability, survivability, and affordability. Performance enhancement objectives are twenty-five percent improvement in endurance, range, and payload of existing helicopters. Sustainability includes increases in operational availability and readiness, and reductions in acoustic susceptibility. Enabling technologies include a dynamically controlled rotor, light-weight high-bandwidth on-blade actuators, and integrated vehicle flight control technologies. Over the past several decades, improvements in helicopter rotor performance have not kept pace with the increasing demands of the warfighter. This is apparent today in the high altitude environment of Afghanistan, where troop and materiel transport missions that are normally performed by the UH-60 Black Hawk are being performed by the much larger CH-47 Chinook due to the loss of performance in high/hot conditions. The Active Rotor program will mature the technologies to enable military aircraft such as the Black Hawk to operate effectively in this environment. The Active Rotor program will focus on development and demonstration of advanced technologies for application to future helicopter and tiltrotor and other rotorcraft platforms, with demonstration on a fielded system to enable application to new systems, and facilitate upgrade of current multi-service rotorcraft rotor systems. The effort will demonstrate technologies with broad applicability to military and commercial helicopters. *FY 2008 Accomplishments:* - Identified promising technologies for advanced lightweight high-bandwidth on-blade actuators, and studied dynamically controlled rotor performance. *FY 2009 Plans:* - Evaluate concepts for novel adaptive rotor systems.		1.591	4.837	7.800	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Characterize performance, survivability and support opportunities and benefits of adaptive rotor technology. - Develop designs for advanced actuators and model performance. *FY 2010 Plans:* - Conduct component technology demonstrations and initiate preliminary design of the Active Rotor System. - Perform sub-scale wind tunnel test of the Active Rotor System.				
Adaptive Morphing Super-Maneuver Aircraft (AMSMA) (U) The goal of the Adaptive Morphing Super-Maneuver Aircraft (AMSMA) program, a follow-on to the Morphing Aircraft Structure (MAS) program previously funded in PE 0602715E, Project MBT-01, is to demonstrate the practicality and the operational value of morphing aircraft technology in a full scale flight demonstration. This effort will lay the foundation for multi-mission aircraft such as a Hunter-Killer UAV platform with revolutionary capability and more broadly, for a new approach to overall aircraft design. AMSMA will build on the small scale demonstrations of the MAS program which established that air vehicles able to seamlessly change configuration in flight are capable of achieving near optimum performance across a range of contradictory missions that would not otherwise be possible with conventional designs. Real-time in flight configuration changing will enable AMSMA to fly efficiently at high or low speeds, to maneuver akin to birds, and to be adaptively survivable. This program will demonstrate an advanced morphing, highly maneuverable air vehicle that achieves high fuel efficiencies, translating to very long endurance times, as much as ten times better than comparative aircraft. It will incorporate a combination of enabling technologies, including asymmetric wing sweep, fore and aft wing translation, and aero-elastic wings with adaptive hinge-less control actuation. If successful, AMSMA could eliminate traditional flying controls while achieving efficient aerodynamic and maneuver performance over a wide range of speeds and altitudes. Shape changing will also be used to establish a new approach to tailored survivability. The AMSMA vehicle has the potential to have a revolutionary impact on prosecution of time sensitive targets. The concept will introduce a capability whereby one aircraft with the ability to effect multiple radical configuration changes is enabled to conduct a range of missions optimally; this provides the prospect of significant affordability gains through reducing the number of different aircraft types in	0.000	4.000	6.200	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
existing military fleets. The AMSMA program will develop a morphing demonstrator vehicle to expand the flight envelope and to demonstrate revolutionary control and a super-maneuver capability through a series of measurable flight experiments. *FY 2009 Plans:* - Identify the capabilities, critical technologies, survivability approaches and performance goals to validate the morphing aircraft concept. - Establish vehicle performance and operating goals. *FY 2010 Plans:* - Develop a morphing concept demonstrator vehicle configuration that will affordably demonstrate optimized mission segment performance (e.g. high-speed dash), will achieve full maneuver capability including extreme new maneuvers, and will optimize tailored survivability.				
Vulcan (U) Constant Volume Combustion (CVC) engines have been under development for more than a decade. Considerable progress has been made and the technology is believed mature enough to enable a dramatic new propulsion system capability. CVC engines, when combined with turbine engines, offer the ability to design a new class of Mach 4+ air breathing engines. The goal of the Vulcan demonstration program is to design, build and ground test an engine capable of accelerating a full scale hypersonic vehicle from rest to Mach 4+. Vulcan will leverage technology advances achieved by the ongoing Reusable Combined Cycle Propulsion (RCCP) program's High Speed Turbine Engine Demonstration (HiSTED) effort, which was previously funded from this project and has transferred to the Air Force Research Laboratory in accordance with the DARPA/AF MOA. The Vulcan engine will consist of a CVC engine, a full scale turbine engine, an inlet and a nozzle. CVC engine architectures could include Pulsed Detonation Engines (PDE's), Continuous Detonation Engines (CDE's) or other unsteady CVC engine architectures. The CVC engine would operate from below the upper Mach limit of the turbine engine to Mach 4+. The turbine engine will be a current production engine capable of operating above Mach 2. Key objectives of the program are to integrate the turbine engine into the Vulcan engine with minimal modification to the turbine engine, to operate the turbine engine from rest to its upper Mach limit, and to	2.100	10.000	0.000	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
cocoon the turbine engine when it is not in use. The Vulcan engine will enable full scale hypersonic cruise vehicles for intelligence, surveillance, reconnaissance, strike or other critical national missions. Beginning in FY 2010, this program will be funded from PE0603286E, Project AIR-01. *FY 2008 Accomplishments:* - Developed Vulcan engine conceptual designs. *FY 2009 Plans:* - Complete engine system requirements review. - Identify all technical risks and develop a critical technology development plan. - Develop Vulcan engine performance models.					
Transformer (TX) Vehicle (U) The Transformer (TX) Vehicle program will examine the feasibility and approaches for developing TX vehicles that can fly for two hours carrying a 1 to 4-person payload on one tank of fuel, can safely travel on roads, and can be operated by a typical soldier. The goal is to define the major components and overall design of a TX vehicle that would be suitable for military scouting, personnel transport, and logistics missions. Technical areas that will be explored include: hybrid electric drive ducted fan propulsion system, ring motors, energy storage methods such as batteries and ultra capacitors, morphing vehicle bodies, and advanced flight controls and flight management systems. The TX vehicle is intended to make roads irrelevant for military small unit maneuvers. These units can use TX air vehicles to fly over obstacles or impassible terrain, avoid ambushes and improvised explosive devices (IEDs). Personal TX vehicles could be dispatched for downed airman recovery or for evacuating injured personnel from difficult to access locations, or to resupply isolated small units. Four-man versions would be suitable for enhanced company operations concepts which would allow the soldier/team to see the situation and pick the best place to “drop in” for urban operations. *FY 2010 Plans:* - Conduct trade studies of vehicle designs, lift motors, flight dynamics and control, energy conversion and storage, vehicle architectures, and concepts of operation.		0.000	0.000	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate preliminary design studies. - Conduct risk reduction experiments and modeling to validate designs.				
Autonomous Aerial Refueling (U) The goal of the Autonomous Aerial Refueling program is to demonstrate the operational feasibility of high altitude refueling between unmanned, limited flight performance aircraft. The program will leverage legacy Global Hawk systems equipped with probe and drogue style refueling hardware and an autonomous refueling system. Specific challenges include achieving a repeatable probability of success with limited flight performance aircraft under high altitude conditions, redundant safe separation and unmanned flight operations, and complex systems integration. The primary benefit will be to enable developers of high altitude long endurance aircraft to confidently employ the advantages of air refueling that have proven so vital to manned aviation. The program will also foster a greater acceptance of increased autonomy in challenging battlespaces, and offers the potential for direct transition to the Global Hawk fleet. *FY 2010 Plans:* - Perform initial requirements allocation and system design. - Conduct modeling and simulation of high-altitude refueling. - Begin aircraft modifications. - Validate drogue performance at altitude (single-ship).	0.000	0.000	8.000	

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
TT-13: NETWORK CENTRIC ENABLING TECHNOLOGY	55.663	69.588	76.332						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Network Centric Enabling Technology project provides technology to build mission applications explicitly tailored to exploit the promise of network-centric system architectures. Mission applications include signal processing, detection, tracking, identification, situation understanding, planning, and control functions. These applications will integrate: 1) external sensors and processors that provide data on targets and mission contexts; 2) external platforms, both air and surface, that deliver sensors and munitions to designated areas; 3) intelligence processing systems at all levels of command; and 4) external communications networks that provide connectivity between computing nodes located on the platforms, at field command centers, and headquarters. The mission applications share data to form consistent battlespace understanding tailored to the needs of commanders at each node. The types of tailoring include common operational pictures, timelines, and resource usage descriptions. The mission applications also negotiate plans for future operations based on mission needs presented at each node. To maintain focus on operationally relevant problems, the project's technical goals are posed and evaluated in the context of mixed manned/unmanned forces.

(U) Technologies developed in this project enable localized and distributed collaborative processing. This allows networks of sensors to rapidly adapt to changing force mixes, communications connectivity, and mission objectives while enabling distributed command and intelligence systems to effectively collaborate in a dynamic environment. Technologies are demonstrated and evaluated in the laboratory and in hardware-in-the-loop demonstrations. Demonstrations employ both stationary and autonomous mobile platforms. Operational benefits are: 1) smaller forward deployment of image and signal analysts in complex operating conditions including urban battlefields; 2) deeper understanding of the evolving stability and support operational environment; 3) consistent integration of target and environment information; and 4) flexible operational tactics and procedures to find evasive targets in difficult environments.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Automated Battle Management	23.790	9.978	0.000	
(U) The Automated Battle Management program is developing novel technologies for multi-platform, automated battle management at the tactical level, in the air, on the ground, and within mobile sensor networks. Such technologies are required if U.S. forces are to keep up with the increasing pace of battle as more-capable platforms and higher-bandwidth communication networks become operational. While experienced commanders are required to formulate strategy and select tactics, the increased operational				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

tempo will demand more automation of low-level decision processes, such as route-finding, weapon/ target pairing, and sensor scheduling. Some elements of these processes, such as collision avoidance and navigation, will be embedded in each platform. However, groups of platforms will be able to execute cooperative tactics to achieve coordinated effects. This cross-platform coordination and synchronization requires new technologies that can carry out aggregate maneuvers and tasks, while leveraging the functions embedded in each platform.

(U) The Collaborative Networked Autonomous Vehicles (CNAV) effort will be the primary demonstration of Automated Battle Management techniques. CNAV will develop autonomous control methods to cause a distributed set of unmanned undersea vehicles to self-organize and distribute tasks through judicious transactions conveyed over a shared communications network. CNAV will utilize these capabilities to provide submerged target detection, localization, and tracking in restrictive littoral waters. CNAV provides this capability by creating a field of dozens or hundreds of vehicles, networked through acoustic wireless communications. The vehicles work collaboratively and autonomously to detect, classify, localize and track target submarines transiting the field. The field self-organizes to adapt to changes in target locations, environmental conditions, and operational factors. A reach-back capability allows reporting of field health and enables high-level orders and control functions to be provided to the field. CNAV will also result in a significant reduction in the cost per square mile for submerged target detection in littoral waters.

FY 2008 Accomplishments:
- Performed intelligent routing of threat characteristic and track data through the field to alert CNAV nodes down stream to position or reposition for target pursuit and intercept.
- Demonstrated fully autonomous and collaborative CNAV field deployment, autonomous field set-up and self-localization, and distributed common tactical operational picture.

FY 2009 Plans:
- Demonstrate collaborative automated target detection, classification, localization and tracking.
- Demonstrate self-healing and reconfiguration, and threat pursuit and interception.
- Demonstrate autonomous recharging, refueling and field establishments to autonomous field deployment.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Video and Image Retrieval and Analysis Tool (VIRAT)*	7.000	16.241	15.159	

*Formerly Combat Zones that See.

(U) The Video and Image Retrieval and Analysis Tool (VIRAT) program will develop and demonstrate a system for video data exploitation that enables an analyst to rapidly find video content of interest from archives and to provide alerts to the analyst of events of interest during live operations. The ability to quickly search large volumes of existing video data and monitor real-time video data for specific activities or events will provide a dramatic new capability to the U.S. military and intelligence agencies. Currently, video analysis for Predator and other aerial video surveillance platforms is very labor intensive, and limited to metadata queries, manual annotations, and “fast-forward” examination of clips. The software tools developed under VIRAT will radically improve the analysis of huge volumes of video data by: 1) alerting operators when specific events or activities occur at specific locations or over a range of locations and; 2) enabling fast, content-based searches of existing video archives. The VIRAT program is developing innovative algorithms for activity representation, matching and recognition which can support both indexing and retrieval. The primary focus of VIRAT is activity-based and dynamic information. Object/scene matching and recognition are also of interest, but only to the extent they support activity analysis. The final product of the VIRAT program is a system that can be transitioned to and integrated within an operational military system, such as the Distributed Common Ground System (DCGS).

FY 2008 Accomplishments:
- Commenced video analysis algorithm development.
- Began development of methodologies for defining descriptors of activities in video and associated indexing and search methods.

FY 2009 Plans:
- Continue developing a set of descriptors for activities in videos.
- Continue developing an efficient indexing method for activity descriptors and an efficient search method against those indices.
- Develop an interactive retrieval process to either alert the user or return to the user matching ‘activities of interest’.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop a system architecture. *FY 2010 Plans:* - Refine and further develop critical technologies to accommodate concatenated and more complex activities. - Continue developing efficient indexing and interactive retrieval against thirty activities. - Extend development of the interactive retrieval process to incorporate improved algorithms and enhanced human factors. - Introduce other airborne video sources and ensure that activity descriptor extraction technologies can still perform as needed.				
Home Field (U) The Home Field program develops networked video and Laser Detection and Ranging (LADAR) processing technology to rapidly and reliably update a 3-Dimensional (3-D) model of an urban area. It provides 3-D situational awareness with sufficient detail and accuracy to remove the “home field advantage” enjoyed by opponents. Detailed mobility maps to support ground vehicle routing will be inferred and generated, and detailed visibility data to support sensor positioning will then be derived to maximize coverage and minimize detectability. High fidelity baselines will be created to support change detection to cue searches for targets and anticipate changes due to current or impending meteorological events. The program will supply real-time context information to sensor managers, maneuver controllers, weapons operators, and commanders. Furthermore, the program will filter natural change from artificial change indicative of human (threat) activity and permit operation of military forces in hostile terrain normally deemed favorable to opponents because of their historical familiarity with hide points, sight lines, and mobility characteristics. (U) Drawing upon technologies developed in the Home Field program, the Urban Photonic Sandtable Display (UPSD) program develops revolutionary interactive holographic displays for complex volumetric 3-D data to replace current 3-D visualization technologies that are either static or have limited effective field-of-view. Current technologies include traditional holography, computer graphics on 2-Dimensional (2-D) screens, slice stacking, parallax autostereo, and goggles/glasses. These techniques not only	11.373	12.513	20.578	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
give a poor image quality and poor movement, they also are not created quickly and do not allow for collaborative viewer interaction. The desire to improve these components has launched the development of the UPSD. Applying the design fundamentals of the monochrome active grouping of pixels for a light modulator element into a single 3-D holographic pixel (hogel-based proof-of-concept) display and further developed module, a scalable and tileable laboratory prototype has been validated by transforming computer data to optical data, making sophisticated integration possible to optimize image quality. The UPSD program will develop an affordable 3-D display that operates at full video rate, displays red-green-blue (RGB) color, increases viewing angle, and increases display size. The result will be the world's first full-motion, full aspect 3-D imaging technology system. Utilizing the technologies developed under the Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM) program in ELT-01, the Emissive Micro Displays program will develop technologies to support the fabrication of Low-cost High pixel density Power efficient Direct emission Microdisplays (LHPDM). Current microdisplay systems use light modulation systems (LCDs, DMDs,) and by using LHPDM, it will enable the transmission of larger fractions of light from the illumination source. *FY 2008 Accomplishments:* - Demonstrated the ability to extract architectural features, such as windows and doors, from close-in imagery. - Built and customized the active hogel modules into tiles and aligned tiles in superstructure for 2-foot by 2-foot and 3-foot by 3-foot systems. *FY 2009 Plans:* - Research advanced technologies for improving the production methods of pixilated emissive displays. - Demonstrate the final reconfigurable system at full video rate, color display, and with the capability of tiling to larger display scales (e.g., 6-feet by 6-feet). - Develop cost effective synthesis methods for Group II-VI and III-V materials. - Utilize controlled arrays of indium gallium nitride (InGaN) to form high efficiency Light Emitting Diode (LED) structures and imaging sensors in IR.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Assemble layer-by-layer heterostructures (characterized by dissimilar materials with non-equal band gaps) from ordered planar arrays of nanocrystals. - Develop and demonstrate techniques for layer doping of heterostructure materials. - Evaluate and select approaches for the development of affordable emissive microdisplays. - Demonstrate initial LHPDM. - Select fabrication technologies with 5 times cost reduction potential. - Commence demonstration of fabrication technologies that support the fabrication of affordable emissive microdisplays.					
Integrated Crisis Early Warning System (ICEWS) (U) The Integrated Crisis Early Warning System (ICEWS) program develops and integrates a set of data analysis tools into a unified information system to support Theater Security Cooperation (TSC). The ICEWS system monitors, assesses and forecasts leading indicators of events that make countries vulnerable to crises. ICEWS technologies include quantitative and computational social science modeling and simulation, scenario generation, ontological modeling of security problems, advanced interactive visualization techniques, and agent-based programming. When integrated, these tools allow combatant commanders and their staff to understand and anticipate conditions that precipitate instability and conflict while there is still time to influence them. ICEWS also helps anticipate unintended consequences of actions taken to influence or remediate situations, consequences that may be delayed by months or years. *FY 2008 Accomplishments:* - Augmented existing social science models with emerging computational social science models and theories. - Built tools to automatically translate the data corpus into a form usable by quantitative and computational social science models. - Developed new crisis monitoring and forecasting models across multiple timescales and levels of analysis.		13.500	10.608	7.895	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Integrate forecasting model components in a real-time analytical system. - Conduct regular experiments to assess predictions in an operational environment. - Create a rigorous analytic capability to predict how alternative courses of action (COAs) are likely to alter adverse emergent patterns. *FY 2010 Plans:* - Conduct in-theater test and evaluation of ICEWS at PACOM HQ. - Develop tools that can be transitioned to the staff at Combatant Commands (PACOM HQ).					
Extreme Accuracy Tasked Ordnance (EXACTO)* *Formerly Laser Guided Bullet. (U) The Extreme Accuracy Tasked Ordnance (EXACTO) program is developing a system that provides sniper teams with the ability to identify and engage targets with heretofore unobtainable range and accuracy against stationary and moving targets under difficult environmental conditions, either day or night. The system uses a combination of a maneuverable bullet and a real-time guidance system to track the target and deliver the projectile to target. Technology development includes the design and integration of aero-actuation controls, power sources, and sensors. The components must fit into the limited volume (2cm to the third power) of a 50-caliber projectile and be designed to withstand a high acceleration environment. When integrated and tested, this system will greatly increase the effectiveness of two-man sniper teams, regardless of the environmental conditions and the time of day. The EXACTO technology is planned for transition to the Army by FY 2012. *FY 2009 Plans:* - Design guidance system. - Design maneuverable projectile. - Construct all novel 1x scale components. - Measure component and subsystem performance in appropriate environments.		0.000	15.670	19.700	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	R-1 ITEM NOMENCLATURE PE 0602702E TACTICAL TECHNOLOGY			PROJECT NUMBER TT-13	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Demonstrate potential performance using Hardware-in-the-Loop (HITL) simulation (based on measured component and subsystem performance) at a number of ranges under a variety of environmental and target conditions. - Perform initial system integration of all subsystems.					
Digital Media Exploitation (MEDEX) (U) The Digital Media Exploitation (MEDEX) program will develop technology to extract intelligence of tactical value from digital media found on computers captured in the field of operations. MEDEX will automatically search content (text documents, audio files, images, videos, applications, etc.) and identify data of high intelligence value. Traditionally, the objective of a digital media exploitation system has been to extract content for later analysis, so accuracy (e.g., precision and recall) and scalability to multiple processors for large data volumes have been emphasized. However, warfighters may have very limited time to process the data for key evidence that may result in tactical advantage; therefore, speed and accuracy are critical. The MEDEX program will develop digital media exploitation technology suitable for tactical environments which have constrained computational resources, accelerated operational timelines, and specific intelligence objectives. The MEDEX program will develop fast algorithms and techniques for processing evidence from digital media to deliver distilled intelligence that is accurate and scalable to large datasets, and can execute quickly on a single mobile computing platform, such as a notebook or ultraportable PC. *FY 2009 Plans:* - Design automated media exploitation algorithms for multiple operating systems and file types. - Design integrated exploitation system that produces ranked lists of summarized content found on digital media. *FY 2010 Plans:* - Develop automated media exploitation algorithms that analyze the intelligence value based on content analysis of text files.		0.000	2.500	4.000	

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APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	R-1 ITEM NOMENCLATURE PE 0602702E TACTICAL TECHNOLOGY		PROJECT NUMBER TT-13

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Integrate algorithms into a digital media exploitation platform capable of producing a human-readable summary of text files. - Demonstrate intelligence extraction by testing digital media.				
Strategic Communication Assessment and Analysis System (SCAAS) (U) The Strategic Communication Assessment and Analysis System (SCAAS) program will develop new theories, concepts, tools and systems to formulate and assess sound strategic communication strategies and measure their effectiveness in influencing allies, adversaries, and other constituencies around the world. Effective strategic communication is central to our ability to effectively deter adversaries, reassure allies, dissuade future competitors, and communicate our resolve to defeat enemies should deterrence fail. The capability developed under SCAAS would have dramatic value to combatant commands as it would enable the influencing of diverse people and organizations abroad towards U.S. National Security interests. *FY 2009 Plans:* - Develop models to continuously analyze/assess the strategic communications "information environment" from multiple perspectives and levels of analysis, including audience, context transmitters, and time. - Develop models for mapping influences to perceptions (such as influences of cultural context, cognitive and emotional biases on message reception and interpretation). *FY 2010 Plans:* - Develop robust analytic methodology to formulate, monitor and assess strategic communication messages and actions, and their contribution toward end-state objectives. - Test and evaluate models and methodologies against several use cases.	0.000	2.078	4.000	
PERsistent Surveillance Exploitation and Analysis System (PerSEAS) (U) The PERsistent Surveillance Exploitation and Analysis System (PerSEAS) program will develop and demonstrate a tool to automatically and interactively identify events of interest from persistent, wide area, motion imagery data. Persistent, wide area surveillance imagery is an ever increasing source of	0.000	0.000	5.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	R-1 ITEM NOMENCLATURE PE 0602702E TACTICAL TECHNOLOGY	PROJECT NUMBER TT-13

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
operational data, but exploitation of this data at present is mostly manual and requires hours to days to produce minimal results. Tools are needed to automatically detect potentially significant adversary activities and to discriminate these from nominal background activity. These tools would be supported by libraries of activity patterns, logic to generate hypotheses about which activities are being observed, and mechanisms to quantitatively score the consistency of the data with each activity hypothesis. Such capabilities are necessary to detect and defeat threats in real-time. Technologies are planned for transition to the U.S. Air Force Distributed Common Ground Station. *FY 2010 Plans:* - Formulate approaches to network discovery based on normalcy estimates, improved tracking algorithms using pattern analysis, and contextual analysis for anomaly detection.				

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.