RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	58.414	71.925	107.857	324.607	230.740	219.032	224.128
Advanced Aerospace Systems AIR-01	58.414	71.925	107.857	324.607	230.740	219.032	224.128

(U) Mission Description:

(U) The Advanced Aerospace Systems program element is budgeted in the Advanced Technology Budget Activity because it addresses high pay-off opportunities to dramatically reduce costs associated with advanced aeronautical systems and provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. Studies conducted under this project include examination and evaluation of emerging aerospace threats, technologies, concepts, and applications for missiles, munitions, and vehicle systems.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Heliplane	14.800	15.400	16.000

(U) The Heliplane program will design, develop and flight test an air vehicle that combines the vertical take-off and landing (VTOL) and low disk loading characteristics of a helicopter with the speed and efficiency characteristics of a fixed wing aircraft. The Heliplane demonstrator aircraft will be tailored to a Combat Search and Rescue (CSAR) mission with a 400 mph cruise speed, a 1,000 lb payload, and an unrefueled range of 1,000 miles. The Heliplane program will conduct a combination of analysis and experiments to develop and demonstrate key enabling technologies. Once key enabling technologies have been demonstrated, a preliminary design of the Heliplane system will be completed, a test of the rotor system will be conducted to demonstrate that the rotor is stable in high-speed flight, detailed design will be completed, and a Heliplane demonstrator will be fabricated and flight tested. Potential customers include the Special Operations Command (SOCOM), Air Force, Marines, Army and Navy.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

(U) Program Plans:

FY 2007 Accomplishments:

- Performed Heliplane system trade studies and developed conceptual design.
- Developed and conducted risk-reduction demonstrations of key Heliplane technologies and components.
- Completed the preliminary design of the rotor.

FY 2008 Plans:

- Complete the preliminary design of an alternate rotor configuration with a > 10 dB reduction in noise from the tip-jet.
- Design and fabricate a scale model to demonstrate capability for stable operation of the Heliplane at high speed in a wind tunnel.

FY 2009 Plans:

- Complete preliminary design of Heliplane demonstrator.
- Complete detailed design of the Heliplane rotor.
- Demonstrate capability for stable operation of the Heliplane at high speed in a wind tunnel.
- Demonstrate tip-jet performance on a whirl stand.

	FY 2007	FY 2008	FY 2009
Oblique Flying Wing (OFW)	16.500	20.150	29.525

(U) An Oblique Flying Wing (OFW) aircraft is an asymmetric flying wing that can vary its wing sweep in flight with increasing speed to optimize aerodynamic performance. The variable sweep is achieved asymmetrically on the oblique wing, with one end of the wing swept forward and the other swept aft. An operational supersonic, variable sweep oblique flying wing holds the promise of being very efficient in both high speed cruise and long endurance low speed loiter. Possible applications that would take advantage of the unprecedented combination of high and low speed performance include: penetrating intelligence, surveillance, and reconnaissance; long range strike; hunter/killer; and multi-mission aircraft. A supersonic aircraft capable of long loiter times would have a revolutionary impact on the battlefield, necessitating fewer combat aircraft and fewer tankers to accomplish mission objectives. The goal of the OFW program is to expand the design space for future aircraft concepts, particularly for those missions that demand both supersonic speed and long endurance. The potential for a unique combination of excellent high speed and low speed performance would enable rapid deployment and long loiter time, for example, in surveillance or combat air patrol (CAP) roles. The OFW program will integrate technologies such as advanced controls to develop and fly a small-scale supersonic

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

technology demonstrator X-Plane. The program will also identify key design requirements for the objective system, allowing the Services to evaluate the technology for implementation in future operational systems. The anticipated transition partner is the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed Oblique Flying Wing (OFW) X-Plane system design.
- Conducted initial subsonic and supersonic wind tunnel tests.
- Completed system requirements review.
- Conducted conceptual design studies of potential operational OFW aircraft.

FY 2008 Plans:

- Conduct stability and control analysis to evaluate predicted trim and handling characteristics of OFW design.
- Complete development of a dynamic flight simulation, which will couple modeling of rigid aerodynamics and aeroelasticity effects for control system development.
- Complete preliminary design review.

FY 2009 Plans:

- Perform additional wind tunnel testing for subsonic and supersonic aerodynamic data, dynamic derivative data and aeroelastic evaluations.
- Initiate procurement of long lead items for X-Plane demonstrator.
- Begin flight test software development and test.
- Continue conceptual design studies of potential operational OFW aircraft.

	FY 2007	FY 2008	FY 2009
Heavy Fuel Engine/Low Friction Engine	5.669	4.935	4.932

(U) The Heavy Fuel Engine/Low Friction Engine program will develop and demonstrate a heavy-fuel, lightweight, and efficient engine for air vehicles. In the future, heavy fuel (diesel or JP-8) may be the only logistic fuel for the battlefield. Conventional heavy fuel engines are too heavy for air vehicles and, at the desired size, not efficient enough. Innovative and advanced diesel engine designs are being developed to achieve both

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

efficiency and a significant reduction in weight. Such engines will enable air vehicles increased maximum range and endurance while operating on diesel fuel. Novel approaches to achieving challenging performance goals include an opposed piston, opposed cylinder (OPOC) concept and a low friction in-line opposed piston configuration. The OPOC engine is designed to achieve sustained high power at high altitude and to minimize the impact of lapse rate. The Low Friction Engine (LFE) is designed to operate without conventional piston rings which are a principal cause of internal combustion engine friction and diminish the amount of useful work that is available from an engine. Detailed design, fabrication, and testing is being conducted to assess engine performance and reliability. Initial engine technology transition planning identified the A160 air vehicle as a promising platform for a heavy fuel engine. Integration of a lightweight heavy fuel engine could double flight endurance for a given weight of fuel. Potential customers include the Army, Special Operations Command (SOCOM), and Marines.

(U) Program Plans:

FY 2007 Accomplishments:

- Successfully completed performance demonstrations of the dual module OPOC prototype engine achieving >36.7% efficiency, a power to weight ratio of >0.92 hp/lb, and producing sea level power of 468 hp (rated at 450 hp at 15,000 ft).

FY 2008 Plans:

- Conduct risk reduction demonstrations of enabling technologies in a single cylinder LFE test engine module to show low friction and viable performance.
- Complete LFE performance, structural and thermodynamic analysis, assessment, and conceptual design.

FY 2009 Plans:

- Demonstrate a four-cylinder LFE for full performance.
- Demonstrate compatibility of prototype engine with the A160 air vehicle.

	FY 2007	FY 2008	FY 2009
Advanced Aerospace System Concepts	3.445	2.440	3.000

(U) Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact/improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; methods to intercept and defeat enemy unmanned air vehicles (UAVs); autonomous refueling for air vehicles; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; air vehicle control, power, propulsion, materials, and architectures; payload and cargo handling systems; and the ability of fixed wing UAVs to perform perch-and-stare missions.

(U) Program Plans:

FY 2007 Accomplishments:

- Performed studies on precision airdrop systems; high altitude, long endurance aircraft; autonomous air refueling; critical strike munitions; and novel propulsion systems.

FY 2008 Plans:

- Investigate the use of novel propulsion systems allowing small fixed wing UAVs to perform perch-and-stare missions.
- Evaluate advanced high-performance rotor system concepts for tiltrotor aircraft
- Perform studies of candidate technologies and develop system concepts.
- Conduct modeling and simulation of system architectures and scenarios.

FY 2009 Plans:

- Analyze materials, designs and techniques for air systems weight reduction and structural efficiency, including complex fittings associated with propulsion and drive system housings and gearbox cases.
- Conduct enabling technology and sub-system feasibility experiments.

	FY 2007	FY 2008	FY 2009
A160	7.000	6.000	4.000

(U) The A160 program will exploit a hingeless, rigid rotor concept operating at the optimum rotational speed to produce a vertical take-off and landing (VTOL) unmanned air vehicle (UAV) with low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2,000 nm) and/or endurance (>20

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

hours). The focus of the remaining program is on the final development and demonstration of the A160 turboshaft variant. Proof of concept flight test will demonstrate platform performance goals, most notably, endurance, a 15,000 feet high altitude hover-out-of-ground effect capability, payload carrying and speed. This program will also demonstrate airworthiness, reliability, and autonomous capabilities of the vehicle. The A160 concept has the potential to meet a range of surveillance and targeting, communications and data relay, crew recovery, resupply of forces in the field, and special operations missions in support of Army, Navy, Marine Corps, and other agency needs. The program also provides a platform for integration and testing of highly efficient heavy fuel engine technologies. These technologies can further advance current range and endurance. The A160 program will transition to the Army and SOCOM after completion of this Phase.

(U) Program Plans:
FY 2007 Accomplishments:
– Achieved performance payload and high speed goals.
FY 2008 Plans:
– Complete expansion of flight envelope and demonstration of flight performance goals to include hover-out-of-ground effect and long endurance flight.
– FY 2009 Plans:
– Transition program to the Army and SOCOM.

	FY 2007	FY 2008	FY 2009
Dual Mode Small Gunship	3.000	0.000	0.000

(U) The Dual Mode Small Gunship program investigated the utility of a low-cost small aircraft, configured with sensors, weapons and special equipment controlled either remotely or by a crew on-board. The ability to have a pilot on-board would allow for easy deployment to theater and safe operation over populated areas by allowing the pilot to interface with the air traffic control infrastructure rather than the current, cumbersome method of deploying large UAVs. The plan to "unman" an existing aircraft would also minimize development costs.

(U) Program Plans:
FY 2007 Accomplishments:
– Completed a preliminary feasibility study for modification of an existing low-cost aircraft.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

	FY 2007	FY 2008	FY 2009
Close Air Support Technology for Loitering Engagement (CASTLE)	1.500	4.000	7.500

(U) The Close Air Support Technology for Loitering Engagement (CASTLE) program will develop alternatives to current, manned systems and explore approaches to provide persistent on-demand overhead fire support with gun-ship like precision, tailored lethal effectiveness and unit directed responsive command and control. The vehicle will demonstrate persistent, sustained mission capabilities with troops on the ground directly commanding the aircraft's weapons and sensors. It will give the ground warfighter particular advantage in urban environments where it will operate with high availability, fast response, precision strike and low collateral damage. Key technologies to be analyzed, developed and integrated under CASTLE include 1) affordable, survivable, and persistent unmanned aircraft, 2) weapons consistent with man-in-the loop close air support application, such as auto-loading Electro Magnetic (EM) guns, directed energy weapons, vertical launch missiles, or deep magazine traditional guns and precision bombs, 3) sensors for targeting and designation, and 4) an adaptive command and control system to permit small unit request, coordination, and direction of supporting fires. Potential customers include the Army, SOCOM, Marines, and AFSOC.

(U) Program Plans:

FY 2007 Accomplishments:

- Evaluated candidate technologies for CASTLE.

FY 2008 Plans:

- Conduct initial concept trade-off for preliminary CASTLE system designs.
- Perform modeling and simulation of alternative candidate air system architectures to assess effectiveness of alternative CASTLE approaches.

FY 2009 Plans:

- Complete preliminary design of air vehicle design concept and development.
- Perform CASTLE technology risk reduction experiments and demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

	FY 2007	FY 2008	FY 2009
Aircraft Self Protection (ASP)	3.000	0.000	0.000

(U) The Aircraft Self Protection (ASP) program explored the active protection of slow moving, high altitude aircraft systems with guided missiles or high energy laser weapons as an alternative/complement to passive defense by signature control. An active aircraft self-defense system could relax the design constraints imposed by signature control, allowing a greater range of platform capabilities. Because lasers provide "speed-of-light" response and a deep magazine, their suitability relative to the more conventional missile based solutions was considered. The ASP program evaluated both pod-mounted and fully integrated system concepts for missile detection, threat tracking, engagement, and defeat at a safe range.

(U) Program Plans:
FY 2007 Accomplishments:
– Performed ASP system trade-off analysis, resulting in system size, weight, power and effectiveness criteria.

	FY 2007	FY 2008	FY 2009
Rapid Eye	0.000	10.500	15.900

(U) The goal of the Rapid Eye program is to develop a high altitude, long endurance unmanned aircraft that can be rocket-deployed from the continental United States world-wide within 1-2 hours to perform intelligence, surveillance, reconnaissance (ISR), and communication missions. The enabling technologies are inflatable/folding structures, stable and dense energy storage, and low-oxygen propulsion. Rapid Eye will provide decision makers rapid-reaction ISR and persistent communication capability for emerging situations. The anticipated transition partner is the Air Force.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

(U) Program Plans:
FY 2008 Plans:
- Perform multi-team conceptual design study of system trades to include launch locations and systems, and aircraft altitude, survivability and endurance; effectiveness; and affordability through modeling and simulation.
- Develop Rapid Eye, risk management plan, and technology and system maturation plan.

FY 2009 Plans:
- Perform subsystem technology development and subscale tests, including sounding rocket, drop, wind tunnel, and high-altitude chamber testing.
- Develop Rapid Eye preliminary design.

	FY 2007	FY 2008	FY 2009
Vulture	0.000	6.500	11.000

(U) The objective of the Vulture program is to develop an aircraft capable of remaining on-station uninterrupted for over five years to perform intelligence, surveillance, reconnaissance (ISR), and communication missions over an area of interest. The technology challenges include development of energy management and reliability technologies capable of allowing the aircraft to operate continuously for five years. Vulture, in effect, will be a retaskable, persistent pseudo-satellite capability, in an aircraft package. The Vulture program will conclude with a year-long flight demonstration with a fully functional payload. The anticipated transition partner is the Air Force.

(U) Program Plans:
FY 2008 Plans:
- Perform multi-team conceptual design study of system trades to include aircraft altitude, survivability, payloads, and missions; effectiveness; and affordability through modeling and simulation.
- Develop risk mitigation and technology maturation plan.
- Begin technology development in the area of energy management.

FY 2009 Plans:
- Maturation of energy management and reliability technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

- Demonstration of component performance and reliability including energy storage, propulsion, and flight management/control systems.
- Initiate construction of a sub-scale demonstrator aircraft.

	FY 2007	FY 2008	FY 2009
Heavy Lift	2.500	0.000	0.000

(U) The Heavy Lift program explored technologies that would lead to novel STOL/VTOL air vehicle concepts and designs. The objective VTOL aircraft would have been optionally-manned and able to lift a 20-ton payload and carry it forward at speeds of 200+ knots with a tactical radius of 400 miles. The program examined technology advances in advanced rotors, propellers, hybrid-mode engines, controls, and advanced composite airframes.

(U) Program Plans:
FY 2007 Accomplishments:
- Performed trade studies.

	FY 2007	FY 2008	FY 2009
Heavy Fuel Engine Development	1.000	0.000	0.000

(U) The Heavy Fuel Engine Development program developed and demonstrated a heavy-fuel (e.g. diesel), lightweight, and efficient engine for air vehicles. Innovative and advanced diesel engine designs are being developed to achieve both efficiency and a significant reduction in overall weight. Such engines provide air vehicles increased maximum range and endurance while operating on a logistic fuel.

(U) Program Plans:
FY 2007 Accomplishments:
- Assessed initial concepts.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

– Completed preliminary design.

	FY 2007	FY 2008	FY 2009
Multi-Modal Missile	0.000	0.000	7.500

(U) The Multi-Modal Missile program will explore the development of an integrated, networked man-portable weapon system capable of performing surface-to-surface, and surface-to-air missions with an emphasis on extreme precision. The program will focus on delivering precision targeting accuracy in both direct and indirect fire modes against multiple targets, and beyond line-of-sight functionality including; armored and soft ground vehicles, bunkers, personnel, helicopters and UAVs. The Multi-Modal Missile will be compatible with existing Javelin and TOW launch infrastructures. The objective Multi-Modal Missile capability will integrate a variety of existing weapons-systems functions and provide both mounted and dismounted soldiers with an affordable compact system. Critical characteristics of this weapon system concept include light weight, simple operation, and affordability. Technologies under consideration will include advanced imaging seekers, precision terminal guidance, propulsion, power storage, vertical launch with lock-on-after-launch capability, and novel warhead concepts to support a wide range of engagement geometries with desired lethality effects against a range of targets. This program was previously funded in PE 0603764E, Project LNW-01. Anticipated service users include the Army, Marines and Special Forces.

(U) Program Plans:
FY 2009 Plans:
– Develop, analyze and assess initial Multi-Modal Missile system preliminary designs and carry out key subsystem technology demonstrations.

	FY 2007	FY 2008	FY 2009
Small UAV Strike Munition	0.000	0.000	4.000

(U) The Small UAV Strike Munition program will develop the technologies to enable a precision guided munition, dramatically reduced in size and cost, for application to airborne unmanned systems and for use by dismounted soldiers/Marines. An inexpensive, low-weight precision

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

guided munition that is effective against soft targets (vehicles, dismounts, conventional structures) can be utilized where expensive precision guided weapons (e.g. Hellfire, intended for armored vehicles) are used today. Employed in an airborne weapon that delivers multiple precision guided sub-munitions, this technology will allow the force to engage an increased number of soft targets at a lower cost, with reduced response time and logistic footprint. A loitering munition with multiple stowed kills can allow successful engagement of high-value, fleeing targets otherwise not possible to detect and engage today. Use of this small munition by dismounts can enable precision fires with a compact warhead size to effectively engage high value targets in complex terrain with minimal collateral damage.

(U) Technical challenges include: a capable precision guidance system and a control system in a package approximately half the size of the most advanced systems currently in development; a low-cost, strap-down sensor capable of autonomously detecting targets with high probability of detection and low false alarm rate, designation by and in close proximity to dismounted soldiers and marines; precision enabling effective target prosecution with dramatically reduced collateral damage; and safe and effective launch from fielded unmanned aircraft and dismounts. Anticipated service users include the Army, Marines and Special Forces.

(U) Program Plans:
FY 2009 Plans:
- Conduct system trades, effectiveness, and affordability studies through modeling and simulation.
- Develop preliminary design, risk management plan, and technology and system maturation plan.

	FY 2007	FY 2008	FY 2009
Stealthy, Persistent, Perch and Stare (SP2S)	0.000	0.000	4.500

(U) The goal of the Stealthy, Persistent, Perch and Stare (SP2S) program is to develop the technology to enable an entirely new generation of perch-and-stare micro air vehicles, based on the Wasp platform, capable of: 1) vertical launch, 2) forward flight to a target, 3) transition from forward flight to hover, 4) vertical landing at the target site, 5) secure, stable attachment to its “perch,” 6) sustained perch-and-stare missions, to include data collection, and 7) at mission end SP2S would re-launch from the perch and fly home. During perch-and-stare, SP2S would perform surveillance and transmit live video/still images beyond line-of-sight back to the home base, utilizing other low altitude UAVs as relay links, as required. Anticipated service users include the Army, Marines and Special Forces.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

(U) Program Plans:
FY 2009 Plans:
- Demonstrate a perch-and-stare prototype.
- Fabricate perch-and-stare field test systems.

	FY 2007	FY 2008	FY 2009
Buoyancy Assisted Lift Air Vehicle	0.000	2.000	0.000

(U) Program Plans:
FY 2008 Plans:
- Investigate a buoyancy assisted lift air vehicle.

(U) **Program Change Summary:** *(In Millions)*	**FY 2007**	**FY 2008**	**FY 2009**
Previous President's Budget	80.474	86.385	95.703
Current Budget	58.414	71.925	107.857
Total Adjustments	-22.060	-14.460	12.154
Congressional program reductions	-10.000	-16.460	
Congressional increases	0.000	2.000	
Reprogrammings	-10.000	0.000	
SBIR/STTR transfer	-2.060	0.000	

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E, Project AIR-01

(U) Change Summary Explanation:

FY 2007	Decrease reflects the reprogramming for DoDEA/DSS, the Section 8043 Recission, and the SBIR/STTR transfer.
FY 2008	Decrease reflects a PE execution adjustment and reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions; offset by a congressional add for Buoyancy Assisted Lift Air Vehicle.
FY 2009	Increase reflects funding of several programs such as SP2S, Multi-Modal Missile, and Small UAV Strike Munition.

(U) Other Program Funding Summary Cost:

A160	FY 2007	FY 2008	FY 2009
Army S&T, Phase I	14.407	0.000	0.000

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2008	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01				
COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	222.300	216.419	287.009	211.510	235.331	250.032	254.221
Space Programs and Technology SPC-01	222.300	216.419	287.009	211.510	235.331	250.032	254.221

(U) Mission Description:

(U) The Space Programs and Technology program element is budgeted in the Advanced Technology budget activity because it addresses high payoff opportunities to dramatically reduce costs associated with advanced space systems and provides revolutionary new system capabilities for satisfying current and projected military missions.

(U) A space force structure that is robust against attack represents a stabilizing deterrent against adversary attacks on space assets. The keys to a secure space environment are situational awareness to detect and characterize potential attacks, a proliferation of assets to provide robustness against attack, ready access to space, the ability to neutralize man-made space environments, and a flexible infrastructure for maintaining the capabilities of on-orbit assets. Ready access to space allows the delivery of defensive systems and replenishment supplies to orbit. An infrastructure to service the mission spacecraft allows defensive actions to be taken without limiting mission lifetime. In addition, developing space access and spacecraft servicing technologies will lead to reduced ownership costs of space systems and new opportunities for introducing technologies for the exploitation of space.

(U) Systems development is also required to increase the interactivity of space systems, space-derived information and services with terrestrial users. Studies under this project include technologies and systems that will enable satellites and microsatellites to operate more effectively by increasing maneuverability, survivability, and situational awareness; enabling concepts include solar thermal propulsion, novel ion-thruster applications, payload isolation and pointing systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Orbital Express Space Operations Architecture	34.711	0.000	0.000

(U) The goal of the Orbital Express Space Operations Architecture program was to validate the technical feasibility of robotic, autonomous on-orbit refueling and reconfiguration of satellites to support a broad range of future U.S. national security and commercial space programs. Refueling satellites would enable frequent maneuver to improve coverage, change arrival times to counter denial and deception and improve survivability, as well as extend satellite lifetime. Electronics upgrades on-orbit provide performance improvements and dramatically reduce the time to deploy new technology on-orbit. The Orbital Express advanced technology demonstration designed, developed and tested on-orbit a prototype servicing satellite (ASTRO) and a surrogate next generation serviceable satellite (NextSat). The elements of the Orbital Express demonstration, coordinated with Air Force Space Command and Air Force Space and Missile Command, was tied together by non-proprietary satellite servicing interfaces (mechanical, electrical, etc.) facilitating the development of an industry wide on-orbit servicing infrastructure. Orbital Express successfully launched in March 2007 as part on the Air Force Space Test Program's STP-1 mission. The demonstration program met all mission success criteria and was completed in July 2007.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed and validated software for autonomous mission planning, rendezvous, proximity operations and docking.
- Designed, fabricated, and tested on-orbit robotic satellite servicing, including fuel and electronics transfer, deployment of and operations with a micro-satellite.
- Performed utility assessments of on-orbit servicing in conjunction with operational customers.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

	FY 2007	FY 2008	FY 2009
Space Surveillance Telescope (SST)	19.771	12.833	7.000

(U) The Space Surveillance Telescope (SST) program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. A major goal of the SST program is to develop the technology for large curved focal plane array sensors to enable an innovative telescope design that combines high detection sensitivity, short focal length, wide field of view, and rapid step-and-settle to provide orders of magnitude improvements in space surveillance. This capability will enable ground-based detection of un-cued objects in deep space for purposes such as asteroid detection and space defense missions. The Air Force will participate in the DARPA funded developmental testing of SST and then take over operation of SST as a sensor in the Air Force Space Surveillance Network. A Memorandum of Agreement (MOA) has been established with Air Force Space Command for transition in FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed and fabricated major components of the 3.5m aperture telescope.
- Designed telescope enclosure.

FY 2008 Plans:

- Develop and fabricate a mosaic of curved focal plane arrays and construct the sensor subsystem.
- Develop, test, and validate software for autonomous telescope operations and data reporting.
- Design and fabricate telescope enclosure and supporting infrastructure at White Sands Missile Range.
- Integrate telescope elements at contractor facility.

FY 2009 Plans:

- Integrate telescope elements on site.
- Validate end-to-end telescope performance and surveillance operations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

	FY 2007	FY 2008	FY 2009
Novel Satellite Communications (NSC)	16.275	15.622	3.800

(U) The aim of the Novel Satellite Communications (NSC) program is the development of a multi-user satellite communications (SATCOM) system that allows ground-based users with handheld radios to communicate with the satellite at high data rates, even when the users are close to multiple jammers and/or located in urban (i.e. severe multi-path) settings. This will be accomplished through novel signal processing, communications and coding techniques. The NSC technology will transition to the Navy (SPAWAR) and Air Force (SMC) following the NSC demonstration in 2009.

(U) Program plans:

FY 2007 Accomplishments:

- Collected experimental SATCOM jamming data using Tracking and Data Relay Satellite System (TDRSS) and Commercial SATCOM satellites, and demonstrated that the NSC algorithms being developed worked on the data collected.
- Developed detailed hardware and software design of the NSC demonstration system.

FY 2008 Plans:

- Conduct additional experimental data collection and processing.
- Finalize design of the NSC demonstration system.
- Begin integration of the NSC System.
- Conduct performance testing of key demonstration subsystems.

FY 2009 Plans:

- Complete assembly of the NSC system.
- Conduct testing and proof of concept demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

	FY 2007	FY 2008	FY 2009
Integrated Sensor is Structure (ISIS)	23.318	29.000	44.000

(U) The Integrated Sensor is Structure (ISIS) program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly-integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes 99% on-station 24/7/365 availability for Simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI) (300 kilometers) operation; 12-plus months of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; responsive reconstitution of failed space assets; plus CONUS-based sensor analysis and operation. The ISIS technology is planned for transition to the Army's PEO Air-to-Surface Missile Defense, Air Force Joint Warfighter Space and the Missile Defense Agency by FY 2011.

(U) Program Plans:

FY 2007 Accomplishments:

- Refined objective system concept designs enabling simultaneous AMTI and GMTI operation, one year logistics-free operation, 99% on-station availability, and high-bandwidth covert communications.
- Developed lightweight technologies for system integration (i.e. high-energy density batteries, electronic circuits on thin-film barrier materials, advanced multi-purpose airship hulls, and regenerative fuel technologies).

FY 2008 Plans:

- Demonstrate lightweight technologies for system integration (i.e. high-energy density batteries, electronic circuits on thin-film barrier materials, advanced multi-purpose airship hulls, and regenerative fuel technologies).
- Develop a preliminary design and fully-operational scaled flight system demonstrating complete system integration over an extended period.

FY 2009 Plans:

- Design and simulate new radar modes; tracking air and ground targets through the clutter notch; detection and response to rockets, artillery, and mortars; detection of dismounted enemy combatant; and "track-all-the-way" fire control.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

- Integrate and flight test a sub-scaled airship demonstrating launch and recovery operations, station-keeping and altitude control algorithms, and validate environmental data models.
- Design and simulate new radar modes; tracking air and ground targets through the clutter notch; detection and response to rockets, artillery, and mortars; detection of dismounted enemy combatant; and "track-all-the-way" fire control.
- Develop a critical design for a fully-operational scaled flight system demonstrating complete system integration over an extended period.

	FY 2007	FY 2008	FY 2009
Deep View	10.250	4.730	0.000

(U) The Deep View program will develop a high-resolution radar imaging capability to characterize objects in earth orbit. A special emphasis will be placed on imaging small objects at orbits ranging from low earth orbit (LEO) to geo-synchronous orbit (GEO). The system will be based upon a large aperture imaging radar system redesigned to operate at very high power over very broad bandwidth at W-band. Key technology development will focus on: (1) transmitters capable of providing the required power to image at deep-space ranges over full bandwidth, and (2) an antenna design that maintains the necessary form factor over a very large aperture. The capabilities emerging from this program will enable the classification of unknown objects, such as space debris, as well as the monitoring of the health and status of operational satellites. DARPA established a joint MOA with the Air Force for this program in August 2004, and technologies developed under the Deep View program are transitioning in FY 2008.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed W-band gyro-twystron transmitter tubes.
- Developed the technology for W-band power combining and frequency multiplexing, to obtain the required transmitter power over the required bandwidth for deep space imaging.
- Completed transmitter and radar system design, retaining the current Haystack X-band capability.

FY 2008 Plans:

- Demonstrate 4-tube gyro-twystron power combining to verify diplexer performance under near-operational conditions.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

– Complete development of advanced signal processing software required by the new broadband high power transmitter approach.

	FY 2007	FY 2008	FY 2009
Long View	9.430	13.809	18.989

(U) The Long View program will develop an inverse synthetic aperture laser radar (LADAR) that will enable the high-resolution imaging of geostationary satellites when coupled to a large aperture telescope. Specifically, the technologies being developed in the Long View program are an optical reference oscillator that is stable over the propagation time to a geostationary satellite (GEOSTAT) and back (about a quarter of a second) and autofocus algorithms that restore image quality that has been degraded due to atmospheric turbulence and optical reference oscillator instability over the imaging time (about 100 seconds). These two technologies are required in order to make inverse synthetic aperture LADAR systems feasible for objects in geostationary orbits. The Long View technology will transition to the Air Force in 2012.

(U) Program Plans:

FY 2007 Accomplishments:
– Designed and began assembling the stable optical reference oscillator.
– Simulated autofocus algorithms.
– Developed and tested autofocus algorithms.

FY 2008 Plans:
– Demonstrate that the stable optical reference oscillator meets stability requirements.
– Demonstrate that the autofocus algorithm is capable of eliminating the blurring due to atmospheric turbulence and stable optical reference oscillator instability over the imaging time.
– Commence design of the Long View demonstration system.
– Conduct measurement of atmospheric turbulence at sub-Hertz frequencies.

FY 2009 Plans:
– Complete design of Long View demonstration system.
– Integrate hardware with telescope.
– Complete measurements of atmospheric turbulence.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

- Fabricate the Long View demonstration system.
- Conduct high-resolution imaging of geostationary satellites.

	FY 2007	FY 2008	FY 2009
Falcon	51.500	25.000	25.000

(U) The Falcon program objectives are to develop and demonstrate hypersonic technologies that will enable prompt global reach missions. This capability is envisioned to entail a reusable Hypersonic Cruise Vehicle (HCV) capable of delivering 12,000 pounds of payload at a distance of 9,000 nautical miles from CONUS in less than two hours. The technologies required by a HCV include high lift-to-drag technologies, high temperature materials, thermal protection systems, and guidance, navigation, and control. Leveraging technology developed under the Hypersonic Flight (HyFly) program, Falcon will address the implications of hypersonic flight and reusability using a series of hypersonic technology vehicles (HTVs) to incrementally demonstrate these required technologies in flight. The HTV-2 program will demonstrate enabling hypersonic technologies for future operational systems through rocket-boosted hypersonic flights with sufficient cross-range and downrange performance to evaluate thermal protection systems, aerodynamic shapes, maneuverability, and long-range communication for hypersonic cruise and re-entry vehicle applications. The HTV-3X program will demonstrate key Hypersonic Cruise Vehicle technologies in a realistic flight environment by developing a re-usable hypersonic aircraft test bed capable of takeoff from runway under turbojet power, acceleration to Mach 6 speed under combined turbojet and scramjet propulsion, controlled deceleration, and runway landings. In order to implement this flight test program in an affordable manner, Falcon will develop a low-cost, responsive Small Launch Vehicle (SLV). The SLV will be capable of launching small satellites into low earth and sun-synchronous orbits and will provide the nation a new, small payload access to space capability. Thus, the Falcon program addresses many high priority mission areas and applications such as global presence and space lift. DARPA established an MOA with the Air Force for the HTV-2 program in May 2003 and with NASA in October 2004. Falcon capabilities are planned for transition to the Air Force.

(U) An MOA with the Air Force in FY 2007 established the HTV-3X Blackswift Test Bed program. Given the importance of this activity, the HTV-3X Blackswift Test Bed has been separately budgeted in FY 2008 and out in this Program Element.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted a second demonstration SLV launch.
- Manufactured an integrated second stage of an SLV.
- Conducted long-duration hot firing tests for second stage VaPak engine.
- Built a new horizontal test stand for more, and longer, second stage hot firings.
- Conducted HTV-2 preliminary design review.
- Conducted HTV-3X feasibility study.
- Conducted wind tunnel testing of HTV-2 outer mold line and completed aero critical design review.
- Completed HTV-2 aeroshell prototype parts fabrication and conducted leading-edge arc-jet test.
- Initiated concept design of the HTV-3X technology flight demonstration vehicle.

FY 2008 Plans:

- Conduct critical design review of HTV-2 demonstration system and initiate fabrication.

FY 2009 Plans:

- Complete assembly, integration, and test (AI&T) of two HTV-2 vehicles.
- Conduct flight testing of HTV-2 vehicles incorporating next generation hypersonic technologies.

	FY 2007	FY 2008	FY 2009
Blackswift Test Bed*	0.000	35.000	70.000

*Formerly Falcon HTV-3X.

(U) The Blackswift Test Bed program will develop an extended duration hypersonic test bed which will allow for the study of tactics for a hypersonic airplane that includes a runway take-off, Mach 6 cruise, and a runway landing. This test bed is an evolution of the reusable Hypersonic Cruise Vehicle developed under the Falcon program. Key technologies that will be demonstrated include efficient aerodynamic shaping for high lift to drag, lightweight and durable (reusable) high-temperature materials and thermal management techniques including active cooling, autonomous flight control, and turbine-based combined cycle propulsion. To accomplish this objective, the Blackswift program will leverage propulsion component technologies developed by the Air Force and DARPA. It is envisioned that flying this hypersonic aircraft test bed in a

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

relevant, flight environment will permit the future development of enhanced-capability reusable high-speed vehicles for intelligence, surveillance, reconnaissance, strike or other national need missions. This program will transition to the Air Force following completion of flight-testing.

(U) Program Plans:

FY 2008 Plans:

- Conduct HTV-3X propulsion trade studies.
- Conduct HTV-3X conceptual design review.
- Conduct further second stage engine firing tests on the horizontal and vertical test stands to validate the VaPak system.

FY 2009 Plans:

- Develop Blackswift preliminary design, risk management plan, and technology and system maturation plan.
- Mature and ground test the scramjet flow path.
- Integrate the scramjet with the high-speed turbine engine.
- Complete a turbine-based combined-cycle propulsion ground demonstration.

	FY 2007	FY 2008	FY 2009
Sleight of HAND (SOH)	9.636	12.710	17.045

(U) The effects of High Altitude Nuclear Detonations (HAND) are catastrophic to satellites. HAND-generated charged particles are trapped for very long periods of time, possibly for years, oscillating between the earth's north and south magnetic poles. This enhanced radiation environment would immediately degrade low earth orbiting (LEO) spacecraft capability and result in their destruction within a few weeks. The Sleight of HAND (SOH) program is a proof-of-concept demonstration of the technology and techniques to rapidly mitigate the HAND-enhanced trapped radiation within days of a HAND event, before LEO spacecraft capabilities are degraded. Other slower remediation methods, taking weeks versus days, would result in spacecraft degradation and would require asset replacement. The SOH effort will explore two alternative approaches to radiation mitigation: 1) using ground transmitted very low frequency (VLF) transmissions to interact with trapped particles and 2) using neutral gas release in space to generate plasma interactions producing ultra low frequency (ULF)/VLF energy to interact with trapped particles. Following laboratory proof-of-concept experiments and a risk reduction sounding rocket flight, a space-based demonstration will be pursued as a pathfinder for a future program in space remediation capability. Potential transition partners include the Navy and Air Force.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

(U) Program Plans:

FY 2007 Accomplishments:

- Developed VLF propagation and radiation interaction/effects model.
- Constructed and deployed an instrumented buoy to sense and report VLF signal strength and effects of VLF on trapped radiation.
- Utilized the HAARP facility to perform 1-hop experiments to anchor VLF propagation and interactions model.
- Performed 2-hop experiments to further enhance the fidelity of VLF prediction codes.
- Performed feasibility studies to determine potential performance of neutral gas release radiation mitigation strategy.

FY 2008 Plans:

- Use results of ground-based SOH experiments to enhance requirements for a space-based SOH demonstrator.
- Develop risk reduction sounding rocket experiment to validate neutral gas release and timing.

FY 2009 Plans:

- Perform risk reduction sounding rocket flight, evaluate results, and incorporate into proposed demonstration.
- Develop preliminary design for space-based SOH neutral gas release demonstration.

	FY 2007	FY 2008	FY 2009
RAD Hard by Design	5.000	4.220	4.705

(U) This program is developing, characterizing, and demonstrating microelectronic design technologies to enable fabrication of radiation hardened electronic components using leading-edge, commercial fabrication facilities. The current mainstream approach for fabricating radiation-hardened electronics depends on specialized process technologies and dedicated foundries that serve this military market niche. While commercial semiconductor fabrication is not explicitly radiation hardened, recent trends in deeply scaled fabrication such as very thin oxides, trench isolation, and multiple levels of metal are resulting in semiconductor devices that are inherently more tolerant of radiation than older generations. This program is pursuing development of design-based technologies that will enable pure commercial fabrication technologies to attain radiation hardened electronics equivalent to those from the dedicated foundries. The design technology developed under the Radiation Hardening by Design program is planned for transition to the Air Force and to the Defense Threat Reduction Agency (DTRA) at the end of Phase II, which is anticipated to be completed by FY 2009. Specific design libraries for hardened circuits will transition through the defense electronics design industry, which are being supported largely by DTRA and the Air Force.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

(U) Program Plans:

FY 2007 Accomplishments:

- Developed a Rad Hard by Design (RHBD) standard cell Application-Specific Integrated Circuit (ASIC) library in a commercial 90 nanometer (nm) complementary metal-oxide-semiconductor (CMOS) process.
- Achieved specified Rad-hard performance metrics with only a "one technology node" penalty in terms of performance, area and power.

FY 2008 Plans:

- Identify candidate system-on-a-chip integrated circuit (IC) to harden utilizing the RHBD standard cell libraries previously developed by this program.
- Fabricate "intermediate" demonstration IC as preliminary to the complete RHBD version of the system on chip (SOC) above.
- Begin exploration of 65 nm technology with respect to RHBD methods.
- Begin exploration of silicon on insulator (SOI) technology with respect to RHBD methods.

FY 2009 Plans:

- Fabricate and test "final" RHBD demo ICs chosen in FY 2008 (90 nm CMOS technology).
- Complete investigation of RHBD efficacy in 65 nm CMOS technology.
- Complete investigation of RHBD efficacy in SOI technology.

	FY 2007	FY 2008	FY 2009
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP)	8.000	10.000	8.000

(U) The Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) will develop the advanced technologies, capabilities, and space environment characterization required to demonstrate a suite of advanced lightweight microsatellite technologies integrated into high performance microsatellites across the continuum from low earth orbit (LEO) to deep space super geo-synchronous orbit (GEO) environment. The program will integrate a variety of advanced technologies, which have not been previously flight-tested, and may include: lightweight optical space surveillance/situational awareness sensors, lightweight power, chemical and electric propulsion systems, advanced lightweight structures, advanced miniature radio frequency (RF) technology including micro crosslink and use of commercial off the shelf (COTS) approaches, active RF sensor technology, COTS processor and software environment, miniature navigation technologies, including the use of

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

starfields for deep space navigation, and autonomous operations. The developed capabilities will include high thrust, high efficiency solar thermal propulsion systems that can enable responsive orbit transfer as well as provide radiation resistant high-density electrical power. The program will also explore ultra-stable payload isolation and pointing systems and components to enable advanced miniature communication systems. In addition, the program will also consider affordable, responsive fabrication and integration approaches and the possibility of networking microsatellites/modules to create a flexible architecture of assets responsive to multiple missions and threats. If successful, MiDSTEP will demonstrate these technologies in space. The anticipated transition partner is Air Force Space Command.

(U) The Microsatellite Technology Experiment (MiTEx) technology demonstration investigated and demonstrated advanced high-payoff technologies from a variety of potential candidates, including: lightweight power and propulsion systems, avionics, structures, COTS components, advanced communications, and on-orbit software environments. MiTEx flight-tested a new, experimental upper stage, and demonstrated small COTS technologies to support a fast-paced, low-cost, lab-like, build-to-launch satellite approach in a shared industry/government environment.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed MiTEx technology demonstration.

FY 2008 Plans:

- Conduct system design trades of appropriate technologies.
- Perform mission utility assessments and feasibility studies and develop concepts of operation.

FY 2009 Plans:

- Design and develop microsatellite system concepts and integrate selected technologies.
- Perform component and subsystem ground tests.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

	FY 2007	FY 2008	FY 2009
System F6	12.224	21.095	37.270

(U) The goal of the System F6 program is to demonstrate a radically new space system composed of a heterogeneous network of formation flying or loosely connected small satellite modules that will, working together, provide at least the same effective mission capability of a large monolithic satellite. Current large space systems used for national security purposes are constrained due to their monolithic architecture. They can be launched only on a small number of large launch vehicles, cannot readily be upgraded and/or reconfigured with new hardware on-orbit, and are risk-intensive, since the unforgiving launch and space environments can result in a total loss of investment with one mistake. The System F6 will partition the tasks performed by monolithic spacecraft (power, receivers, control modules, etc.) and assign each task to a dedicated small or micro satellite. This fractionated space system offers the potential for reduced risk, greater flexibility (e.g. simplified on-orbit servicing, reconfigurability to meet changing mission needs), payload isolation, faster deployment of initial capability, and potential for improved survivability. This program will develop, design, and test new space system architectures and technologies required to successfully decompose a spacecraft into fundamental elements. Such architectures include, but are not limited to, ultra-secure intra-system wireless data communications, wireless power systems, electromagnetic formation flying systems, remote attitude determination systems, structure-less optical and RF arrays, distributed spacecraft computing systems, and reliable, robust, rapidly re-locatable ground systems. The anticipated transition partner is the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted system design trades of appropriate technologies and system architectures.
- Performed mission utility and econometric-based value assessments and feasibility studies and developed concepts of operations.

FY 2008 Plans:

- Design and develop fractionated system concepts and integrate selected technologies.
- Formulate econometric value-modeling methodologies to inform system engineering trade decisions.
- Conduct Hardware-In-the-Loop (HIL) demonstrations of successively greater capability simulating wireless network operating environment for fractionated satellite systems.
- Develop trajectories for launch, deployment and sustainment of cluster satellite systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

– Review feasibility of wireless power transfer approaches for inter and intra-satellite operations.

FY 2009 Plans:

– Perform component and subsystem ground tests.
– Conduct Hardware-In-the-Loop (HIL) demonstrations of successively greater capability simulating 1) wireless network operating environment for fractionated satellite systems, 2) orbit propagation with real world dynamics, 3) guidance, navigation and control schemes, 4) cluster flying algorithms, and 5) distributed resource management.
– Refine system design to provide a detailed description of spacecraft and ground modules, subsystem-level allocation of mass, power and reliability, trade space definition for each component/technology, and risk analysis with mitigation schemes.

	FY 2007	FY 2008	FY 2009
Front-end Robotics Enabling Near-term Demonstration (FREND)	13.196	14.400	10.700

(U) The goal of the Front-end Robotics Enabling Near-term Demonstration (FREND) program is to develop, demonstrate and fly robotic manipulator technologies designed to allow interaction with geosynchronous orbit (GEO)-based military and commercial spacecraft, extending their service lives and permitting satellite repositioning or retirement. Existing GEO spacecraft are outfitted with sufficient propellant to provide for needed station keeping, repositioning, and retirement maneuvers, which in many cases defines their useful mission durations. Once this propellant is expended, the vehicle is retired and, in many cases replaced. FREND technologies can enable significant service extension to these spacecraft through re-boosting near end-of-life. FREND combines detailed stereo photogrammetric imaging with robotic multi-degree-of-freedom manipulators to autonomously grapple space objects not outfitted with custom interfaces. A FREND-based servicing spacecraft offers the potential for spacecraft salvage, repair, rescue, reposition, de-orbit and retirement, and debris removal. The anticipated transition partner is the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:

– Designed, fabricated, and ground tested the rendezvous sensor and robotic payload elements.
– Conducted risk reduction lab testing.
– Developed control algorithms for autonomous grapple and contingency operations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

FY 2008 Plans:
- Procure and fabricate flight hardware for integration and testing.
- Conduct robotic payload ground test.
- Test control schemes in 1G environment.

FY 2009 Plans:
- Conduct hardware-in-the loop testing in proximity operations test facility.
- Work with mission partner to develop demonstration mission.

	FY 2007	FY 2008	FY 2009
Fast Access Spacecraft Testbed (FAST)	4.300	7.000	12.000

(U) The goal of the Fast Access Spacecraft Testbed (FAST) program is to demonstrate a suite of critical technologies required to perform rapid orbital repositioning in the geosynchronous belt. The ultimate goal of FAST is to demonstrate technology to enable a high-efficiency, high-power (50-80 kW), fast-transfer roaming satellite permitting on-demand access to any point on the geosynchronous ring or within the high-altitude, super synchronous "graveyard" (where derelict systems are regularly repositioned in order to free up orbital slots within the ring), greatly improving our space situational awareness capabilities. The FAST demonstrator satellite, while possessing high power (20 kW or more), would be revolutionary in its small size. At just 500 kilograms, a FAST spacecraft would carry a novel solar power collection and distribution system, composed of large-aperture (5-10 m diameter) concentrating mirrors, high-efficiency solar photovoltaics, and ultra-lightweight, deployable radiators, achieving specific power (130 watts/kilogram at the power subsystem level) figures an order of magnitude better than today's state of the art. The anticipated transition partner is the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:
- Conducted system design trades and investigated utility of applicable power and propulsion technologies.

FY 2008 Plans:
- Perform preliminary design and technology selection.
- Perform detailed design, development, and ground testing of the FAST spacecraft high-power generation subsystem.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

FY 2009 Plans:

– Initiate design and development of the FAST demonstrator spacecraft.

	FY 2007	FY 2008	FY 2009
NanoPayload Delivery (NPD)	0.000	3.000	6.000

(U) The goal of the NanoPayload Delivery (NPD) program is to validate the technical feasibility of ultra-lightweight, rapid-response spacecraft delivery from land, sea, or air-based platforms. Such nanopayloads (1-10 kilograms) could be boosted to low earth orbit (200 km altitude) in a matter of hours following call-up. Multiple sorties are envisioned, enabling a number of small spacecraft to be placed in an orbit "box" and aggregated together to perform a mission. The NPD program will develop and test a lightweight rocket platform similar in size to existing small missile systems such as the High-Speed Anti-Radiation Missile (HARM), AIM-7, or AIM-120. Current technology does not permit such small systems to reach orbit, owing to disproportionately high drag and low thrust-to-weight rocket engines. NPD will leverage ongoing technology development efforts, which permit the fabrication of microscale pumps, thrust chambers, and valves. Such rocket engines, which are theoretically capable of thrust-to-weight ratios of 100:1 or greater, would allow for significant reductions in overall engine mass and permit nanosatellites to be placed in low orbits for several weeks to months. The delivery system would rely on one of several methods for launch, including: (1) a stock aircraft, such as the F-15E or F-16, (2) a truck-mounted erector, or (3) the deck of a small naval vessel. The goal for per-sortie cost is $100,000. Fielding NPD will permit U.S. forces to rapidly emplace short-term capabilities in low orbit, when they are needed, without resorting to legacy domestic launch systems that are sized and costed for much larger payloads. NPD will also allow many non-traditional users (e.g. laboratories, operational commanders, and small commercial firms) the capability to "use space" by lowering the significant barrier to entry into space. NPD will allow a streamlined, inexpensive approach to launch, descoping lengthy test and documentation requirements and demanding far fewer engineers, technicians, range personnel, and spacecraft operators per mission. Potential transition customers include the Air Force and Navy.

(U) Program Plans:

FY 2008 Plans:

– Survey existing aircraft-, land-, and sea-based missile platforms for compatibility with NPD mission constraints and requirements.
– Design, fabricate, and test an integrated micro chemical engine; including pumps, lines, valves, and thrust chamber; to validate performance models.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

FY 2009 Plans:
- Design, develop, and test arrays of micro engines for use as the first and upper stages of the NPD rocket platform.
- Integrate and test micro engine arrays on selected missile platforms.

	FY 2007	FY 2008	FY 2009
Space Situational Awareness & Counterspace Operations Response Environment	0.000	4.000	7.000

(U) The goal of the Space Situational Awareness (SSA) & Counterspace Operations Response Environment (SCORE) program is to develop and demonstrate an operational framework and responsive defense application to enhance the availability of vulnerable commercial space-based communications resources. SCORE will correlate a wide range of operational support and space system ground user data to rapidly identify threat activities, propose mitigating countermeasures, and verify the effectiveness of selected responses. Critical technologies include accessing disparate sources of relevant data, model-based situational awareness, and candidate response generation and evaluation. Particular emphasis will be placed on the ability to continuously adapt to changes in defended system components and usage patterns as well as validation of SCORE system integrity. The potential transition customer is the Air Force.

(U) Program Plans:

FY 2008 Plans:
- Develop initial system requirements and design.
- Develop adaptive model of defended systems and identify relevant sources of data.

FY 2009 Plans:
- Conduct system trades and validate critical components.
- Mature system parameters and operational procedures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

	FY 2007	FY 2008	FY 2009
MEO Synthetic Aperture Radar (MEOSAR)	0.000	0.000	4.000

(U) Synthetic Aperture Radar (SAR) integration time is currently limited by the amount of ground vehicle motion encountered during the synthetic aperture collection time. For space radar systems, this has traditionally meant that SAR had to be accomplished at low earth orbit (LEO) trajectories where the collection time would be much shorter given the high speeds of a LEO satellite. Although the specifics depend heavily on geometric considerations, medium earth orbit (MEO) SAR imaging intervals can be a factor of approximately eight longer, compared to a LEO alternative. The longer integration times required at MEO can have a major impact on the quality of the otherwise equivalent SAR image due to the presence of internal motion within the image scene. To achieve equivalent quality imagery, the contribution of the moving targets within the image must be excised. The MEOSAR program will develop techniques to identify moving targets and extract them from the data prior to imaging to avoid the streaking caused by their motions. The program will develop reliable automated detection of moving targets within SAR imagery using a double thresholding process in interferometric phase and amplitude. This moving target detection technique can be readily reversed to excise the moving targets from the clutter (image) background. Temporal sub-array processing will demonstrate early detection and rejection of moving targets in sub-array images. The program will develop improved motion detection and removal algorithms, demonstrate their performance on simulated and airborne data, and develop an architectural concept for a MEOSAR system. This program will transition to the Air Force and STRATCOM in FY 2013.

(U) Program Plans:

FY 2009 Plans:

- Develop algorithms to identify moving targets and extract them from the data prior to imaging to avoid the streaking caused by their motions.
- Demonstrate algorithms on emulated data sets.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

	FY 2007	FY 2008	FY 2009
Bi-Static Shield	0.000	0.000	4.500

(U) The Bi-Static Shield will utilize existing satellite tracking, telemetry and control (TT&C) radio frequency (RF) illumination beams to create an electromagnetic (EM) shield in the immediate satellite vicinity (within a 30km radius from the geosynchronous orbit (GEO) satellite). Using the satellite omni antennas to serve as bi-static receivers, reflections from intruder satellites could be detected up to 10km from GEO spacecraft by extracting the very weak bi-static illumination signals reflected off the intruder satellites. Use of existing satellite TT&C transmit antennas to generate a bi-static EM shield would provide a very important situational awareness capabilty without the need for additional on-orbit assets around individual satellites. The Bi-Static Shield program is planned for transition to the Air Force for space situational awareness applications in FY 2012.

(U) Program Plans:
FY 2009 Plans:
- Conduct modeling and simulation to determine algorithms required.
- Develop software required to decipher received reflections.
- Upload and conduct over-the-air test using Tracking and Data Relay Satellite System (TDRSS) or other suitable cooperative satellite and satellite ground station.

	FY 2007	FY 2008	FY 2009
High Delta-V Experiment (HiDVE)	0.000	4.000	7.000

(U) The goal of the High Delta-V Experiment (HiDVE) program, an outgrowth of the MiDSTEP program, is to design, develop, and demonstrate a low-mass, low-volume, high delta-V solar thermal propulsion (STP) engine suitable for integration with a ~15kg nanosatellite host. The enabling technologies are very high-temperature materials and innovative receiver and concentrator designs. A HiDVE system will provide small satellites, historically constructed without propulsive capability, with substantial delta-V affording nanosatellites increased orbital range, in terms of both attitude and plane. In addition, this flexibility will be essential to future nanosatellite mission designers and operators, who will be

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

able to take advantage of less-than-optimal insertion orbits and later move to an intended mission orbit. Specific objectives of the HiDVE program include: development and demonstration of a functioning STP system in a relevant environment; an operational test plan that outlines the steps needed to flight-qualify an integrated nanosatellite with an STP system.

(U) Program Plans:
FY 2008 Plans:
– Develop a functioning high delta-V solar thermal propulsion system in a relevant environment.
FY 2009 Plans:
– Develop and ground demonstrate low-cost, low-volume solar thermal propulsion prototypes.

	FY 2007	FY 2008	FY 2009
Micro Electric Space Propulsion (MEP)	4.689	0.000	0.000

(U) The Micro Electric Space Propulsion program (MEP) would have demonstrated flexible, lightweight, high-efficiency, scalable micro-propulsion systems to enable a new generation of fast, long-lived, highly flexible, and highly maneuverable 1-100 kg-class satellites/spacecraft.

(U) Program Plans:
FY 2007 Accomplishments:
– Demonstrated core technology by showing sustained ion emission from an array of micro-fabricated microelectromechanical (MEMS) field effect electric propulsion (FEEP) thrusters.

(U) **Program Change Summary:** *(In Millions)*	**FY 2007**	**FY 2008**	**FY 2009**
Previous President's Budget	253.950	224.551	225.238
Current Budget	222.300	216.419	287.009

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

Total Adjustments	-31.650	-8.132	61.771
Congressional program reduction	0.000	-8.132	
Congressional increases	0.000		
Reprogrammings	-25.149		
SBIR/STTR transfer	-6.501		

(U) Change Summary Explanation:

FY 2007	Decrease reflects the Innovative Space-Based Antenna Technology (ISAT) reprogramming and the SBIR/STTR transfer.
FY 2008	Decrease reflects the cancellation of the MEP program and reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.
FY 2009	Increase reflects funding of the Blackswift Test Bed and expansion of the System F6 and Sleight of HAND programs.

(U) Other Program Funding Summary Cost:

Falcon	FY 2007	FY 2008	FY 2009
PE 0604855, Air Force SPC	5.600	0.000	0.000
PE 0604856, Air Force SPC	26.500	23.500	11.000

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01

Deep View	FY 2007	FY 2008	FY 2009
PE 0305940F, Air Force SPC	13.576	8.859	0.000

Space Surveillance Telescope	FY 2007	FY 2008	FY 2009
USAF	0.000	0.000	1.100

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technology; PE 0603739E

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	212.889	202.942	201.146	198.712	194.939	203.418	203.416
Centers of Excellence MT-07	5.625	5.500	0.000	0.000	0.000	0.000	0.000
MEMS and Integrated Microsystems Technology MT-12	80.077	39.470	57.057	63.886	71.806	80.721	80.720
Mixed Technology Integration MT-15	127.187	157.972	144.089	134.826	123.133	122.697	122.696

(U) Mission Description:

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

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

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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E

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

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

(U) **Program Change Summary:** *(In Millions)*	**FY 2007**	**FY 2008**	**FY 2009**
Previous President's Budget	243.728	220.548	232.383
Current Budget	212.889	202.942	201.146
Total Adjustments	-30.839	-17.606	-31.237
Congressional program reductions	-10.000	-21.346	
Congressional increases	0.000	3.740	
Reprogrammings	-14.600		
SBIR/STTR transfer	-6.239		

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E

(U) Change Summary Explanation:

FY 2007	Decrease reflects the Section 8043 Recission, the OMNIBUS reprogramming, an internal reprogramming, and the SBIR/STTR transfer.
FY 2008	Decrease reflects a PE execution adjustment and reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions; offset by congressional adds for Computing and NanoscaleElectronic Processing, MilTech Extension program, and Ultra Low Power Electronics for Special Purpose Computers.
FY 2009	Decrease reflects the completion of several programs in the Mixed Technology Integration Project (MT-15), including Ultra-Wideband Technology, High Operating Temperature – Mid-Wave Infrared (HOT MWIR), Space, Time Adaptive Processing (STAP) BOY, and Electronics and Phonic Integrated Circuits on Silicon; offset by an increase in MEMs and Integrated Microsystems Project (MT-12) for new chip scale and nanofabrication efforts.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Centers of Excellence MT-07	5.625	5.500	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

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

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Advanced Flexible Manufacturing	4.000	4.000	0.000

(U) Program Plans:

FY 2007 Accomplishments:

- Assessed the Institute for Advanced Flexible Manufacturing's performance and worked toward transitioning from DoD to state/private support.

FY 2008 Plans:

- Continue to assess the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07

	FY 2007	FY 2008	FY 2009
Defense Techlink Rural Technology Transfer Project	1.625	1.500	0.000

(U) Program Plans:
FY 2007 Accomplishments:
– Provided funding for the Defense Techlink Rural Technology Transfer Project.
FY 2008 Plans:
– Continue to provide funding for Defense Techlink Rural Technology Transfer Project.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2008	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12				
COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
MEMS and Integrated Micro-systems Technology MT-12	80.077	39.470	57.057	63.886	71.806	80.721	80.720

(U) Mission Description:

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

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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Micro Power Generation	6.094	3.000	0.000

(U) Compact portable power sources capable of generating power in the range of a few hundred milliwatts to one watt are critical to providing power for untethered sensors and other chip-scale microsystems. This program will replace today's technologies relying on primary and rechargeable batteries, which severely limit mission endurance and capabilities, by extending microelectronic machine technology to develop micro-power generators based on mechanical actuation and thermal-electric power generation. Operating with traditional fuels, these micropower generators will be capable of generating sustained power in the desired range for use with remote, field-deployed microsensors and microactuators. The program will also explore innovative micro-scale, integratable power sources to provide high-density energy sources. The Micro Power Generation program is anticipated to transition via industry to dismounted warrior and unattended ground sensor network programs under development by the Army.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated capabilities in fuel processing, energy conversion to electricity, and thermal and exhaust management.
- Demonstrated MEMS micro heat engines utilizing micropower sources.

FY 2008 Plans:

- Demonstrate integration of various power-generation components with microsensors and microactuators.
- Demonstrate stand-alone, remotely distributed microsensors and actuators with built-in power supply and wireless communication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

	FY 2007	FY 2008	FY 2009
Harsh Environment Robust Micromechanical Technology (HERMIT)	10.585	2.767	3.990

(U) The Harsh Environment Robust Micromechanical Technology (HERMIT) program is developing micromechanical devices that can operate under harsh conditions - e.g., under large temperature excursions, large power throughputs, high g-forces, corrosive substances, etc. - while maintaining unprecedented performance, stability, and lifetime. Micromechanical RF switches are of particular interest, where sizable power throughputs and impacting operation constitute harsh operational environments. Other applications such as vibrating resonator reference tanks, gyroscopes, and accelerometers are also of interest. Among the HERMIT implementation approaches deemed likely to succeed are two of most interest: 1) wafer-level encapsulation or packaging strategies based on microelectromechanical systems (MEMS) technology that isolate a micromechanical device from its surroundings while maintaining a desired environment via passive or active control; or 2) material and design engineering strategies that render a micromechanical device impervious to its environment, with or without a package (if possible). A key approach in this program that should allow orders of magnitude power savings is to selectively control only the needed micro-scale environment or volume via MEMS-enabled isolation technologies. The success of this program should enable a myriad of strategic capabilities including lower cost, more complex phased array antennas for radar applications; tiny frequency references with long- and short-term stabilities that greatly extend the portability of ultra-secure communications; and micro-scale inertial measurement units with bias stabilities approaching navigation-grade. The HERMIT program is anticipated to transition via industry to phased array antenna, reconfigurable communication front-end, seeker, and steerable aperture programs being developed by the Army, Navy, and Air Force, as well as to inertial navigation systems and Joint Tactical Radio System (JTRS) communications needed by these Services.

(U) Program Plans:

FY 2007 Accomplishments:

- Established the feasibility of encapsulating micromechanical devices under low-cost, wafer-level packages with minimal out-gassing or leaking and with minimal impact on device performance.
- Demonstrated engineered materials and/or surface treatments that render a micromechanical device impervious to its surroundings or operating environment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

FY 2008 Plans:

– Demonstrate essential elements (e.g., thermistors, heaters, getters, etc.) needed for low power control of the operating environment surrounding a micromechanical device.

FY 2009 Plans:

– Demonstrate micromechanical devices (e.g., RF switches, vibrating resonators, etc.) fully integrated together with environment isolating measures (including circuits, if any) that maintain unprecedented performance, stability, and reliability, even under harsh environments.

	FY 2007	FY 2008	FY 2009
Chip-Scale Micro Gas Analyzers	20.504	5.267	0.000

(U) The Chip-Scale Micro Gas Analyzers program will utilize the latest microelectromechanical systems (MEMS) technologies to implement separation-based analyzers (e.g., gas chromatographs, mass spectrometers, poly-chromator-like devices) at the micro-scale to greatly enhance the selectivity of sensors to specific species, and thus, enable extremely reliable, remote detection of chemical/biological agents. The use of MEMS technology should also increase analysis speed and make possible the operation of such complex analyzer systems at extremely low power levels-perhaps low enough for operation as autonomous, wireless sensors. The many challenges in this program include the exploration and realization of micro-scale preconcentrator approaches, stacked gas columns, multiple sensor arrays, ionizers, vacuum pumps, and vacuum packaging. The success of this program will yield sensors substantially more selective than conventional sensors, again, making them particularly suitable for detection and identification of airborne toxins. The Chip-Scale Gas Analyzers program is anticipated to transition via industry to Chemical Warfare Agents (CWA) detector programs being developed by the Defense Threat Reduction Agency (DTRA) and the Army Soldier and Biological Chemical Command (SBCCOM).

(U) Program Plans:

FY 2007 Accomplishments:

– Established design trade-offs in (column) length vs. species separation efficiency for micro-scale gas chromatographs, mass spectrometers, resonator-based separation mechanisms, etc.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

– Demonstrated MEMS-enabled, micro-scale preconcentrators and explored the degree to which they enhanced separation efficiency and species detectability.

FY 2008 Plans:

– Demonstrate MEMS-enabled, micro-scale separation columns, ionizers, electromagnetic field generators, vacuum pumps, gas sensor arrays, calibration sources, all needed for separation-based analyzers.
– Demonstrate advanced methods for making micromechanical sensor elements species sensitive (e.g., combinations of absorption spectroscopy and resonators coated with species-and-light sensitive films).
– Implement fully functional, MEMS-enabled gas separation analyzers with power consumptions small enough for autonomous, remote operation and control electronics integrated directly.

	FY 2007	FY 2008	FY 2009
MEMS Exchange	7.250	2.908	1.000

(U) The MEMS Exchange program seeks to provide flexible access to complex microelectromechanical systems (MEMS) fabrication technology in a wide variety of materials and to a broad, multi-disciplinary user base via the MEMS Exchange service. A major goal of the effort is to ensure self-sustained operation of MEMS Exchange after the end of the program by adding several process modules to the existing repertoire and increasing the number of processes run per year to raise revenues to the point of self-sufficiency. Among the future payoffs of this program is the establishment of an accessible infrastructure for low or medium volume production of MEMS-enabled products for DoD applications. The goal of the MEMS Exchange program is self-sufficiency at which point it will be able to provide MEMS fabrication services to all levels of industry and academia in support of Army, Navy, Air Force, and other DoD requirements without further DARPA sponsorship.

(U) Program Plans:

FY 2007 Accomplishments:

– Demonstrated online software capable of error checking and optimized process flow input by users, which reduced the turn-around time per run and increased success rates.
– Inserted a MEMS process module into the MEMS Exchange repertoire and made it available for use.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

FY 2008 Plans:
- Double the number of runs processed per year, to achieve a goal rate of 500 runs per year.
- Provide a modular merging process that combines modules together with transistor integrated circuits.

FY 2009 Plans:
- Insert MEMS technology into three DoD applications using MEMS Exchange as the fabrication vehicle.

	FY 2007	FY 2008	FY 2009
Low Power Micro Cryogenic Coolers	5.230	3.450	0.810

(U) The Low Power Micro Cryogenic Coolers program will attain superior performance in micro-scale devices (e.g. Low Noise Amplifier (LNA's) IR detectors, RF front-ends, superconducting circuits) by cooling selected portions to cryogenic temperatures. The key approach in this program that should allow orders of magnitude power savings is to selectively cool only the needed volume/device via MEMS-enabled isolation technologies. Such an approach will benefit a large number of applications where performance is determined predominately by only a few devices in a system, e.g., communications where the front-end filter and LNA often set the noise figure; and sensors, where the transducer and input transistor in the sense amplifier often set the resolution. MEMS technology will also be instrumental for achieving micro-scale mechanical pumps, valves, heat exchangers, and compressors, all needed to realize a complete cryogenic refrigeration system on a chip. Transition of this technology is anticipated through industry, who will incorporate elements of the technology in current and future weapon system designs.

(U) Program Plans:

FY 2007 Accomplishments:
- Demonstrated thermal isolation of >10,000 kilowatt (K/W) in a silicon micromachining process.
- Demonstrated on-chip cooling to 77 kilo (K) using a photonic fiber heat exchanger.
- Demonstrated new localized on-chip cooler approaches using integrated thermoelectric coolers and photonic heat exchangers.

FY 2008 Plans:
- Demonstrate micro-scale coolers capable of providing the needed cryogenic temperature while still fitting into a miniature size, with sufficient efficiency for low power operation.
- Demonstrate heat exchangers, Joule-Thompson plugs, valves, pumps, all needed for cryo-cooler implementation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

FY 2009 Plans:
- Integrate micro cooler components together with sufficiently isolated devices to-be-cooled to yield a single chip system consuming very little power.

	FY 2007	FY 2008	FY 2009
Microsystem Integrated Navigation Technology (MINT)*	9.000	5.230	7.096

*Formerly titled Chip-Scale Atomic Sensors.

(U) The Microsystem Integrated Navigation Technology (MINT) program is developing technology for precision inertial navigation coupled with micro navigation aiding sensors. The MINT program will develop universally reconfigurable microsensors (e.g., for magnetic fields, temperature, pressure) with unmatched resolution and sensitivity. These devices will use the latest in MEMS and photonic technologies to harness perturbations in atomic transitions as the sensing and measuring mechanisms for various parameters. Program transition will occur through industrial performers into future DoD platforms.

(U) Program Plans:

FY 2007 Accomplishments:
- Developed a tunable microwave local oscillator to excite and select different hyperfine transitions.

FY 2008 Plans:
- Develop technology to dramatically reduce bias drifts in Complementary Metal-Oxide Semiconductor (CMOS)-integrated MEMS accelerometers and gyros.
- Develop CMOS-MEMS sensors for precision navigation aids such as velocity ranging and zero-velocity updating.

FY 2009 Plans:
- Reduce power and volume requirements.
- Develop technologies to harvest power through energy scavenging.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

	FY 2007	FY 2008	FY 2009
Thermal Ground Plane (TGP)*	15.894	7.848	8.161

*Formerly titled Site-Specific Thermal Management (SSTM).

(U) The Thermal Ground Plane (TGP) program will develop new approaches to removing local hot-spots that limit the performance of high-speed signal processing electronics, radar imaging systems, optoelectronic devices, and other systems characterized by above-ambient thermal issues. This program will provide a natural complement to the Low Power Micro Cryogenic Coolers program by addressing the performance-critical issue of excessive heat removal. The TGP program will consider both monolithic and heterogeneous thermal management approaches based on variety of thermal materials and heat removal methods. Examples include self-powered liquid spray cooling, integral copper heat pipes, microfluidic channels and diamond interposer layers. This technology is lowering power consumption and overall cooling requirements and will be inserted through DoD industrial firms into future DoD systems.

(U) Program Plans:

FY 2007 Accomplishments:

– Initiated review of thermal management approaches.

FY 2008 Plans:

– Identify and apply new integrated technologies for the thermal management of microsystems.

FY 2009 Plans:

– Develop and integrate cooling approaches using new materials.

	FY 2007	FY 2008	FY 2009
Micro-Beam Clocks	2.602	2.000	4.000

(U) The Micro-Beam Clock program will extend the accuracy of Chip Scale Atomic Clock (CSAC) by exploiting the precision of nuclear particle transport. The concept of beam clock has been known at least since the 1960's but has not been widely pursued due to the difficulty in containing a large volume of xenon gas. This problem will be addressed by going to the micro-scale. Miniaturization of the conventional beam

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

clocks with major innovations are possible due to microscale implementation – microscale xenon atom source, micromachined permanent magnets, and micromechanical atom flux detectors. This approach will not only improve the stability over existing CSAC but will further reduce the required power. This technology will be transitioned into DoD systems through innovative companies, including performers under the Chip-Scale Atomic Clock program.

(U) Program Plans:

FY 2007 Accomplishments:

– Generated sufficient atom flux using adsorption-desorption control at microscale.
– Detected atoms in flight using micro-cantilever array – Brownian noise limited.

FY 2008 Plans:

– Determine permanent magnet laser cutting at microscale.
– Determine High B-field gradients at microscale.

FY 2009 Plans:

– Determine pressure measurement in presence of high magnetic field with MEMS pressure sensors.

	FY 2007	FY 2008	FY 2009
Nano-Electro-Mechanical Computers (NEMS)	1.818	7.000	9.000

(U) The goal of the Nano-Electro-Mechanical Computers (NEMS) program is to develop nanoscale mechanical switches and gain elements integrated intimately with complementary metal-oxide semiconductor switches. One mechanical switch per transistor will enable the transistor to operate at near zero leakage powers, enabling pico or femtowatt standby operation. The program will also develop mechanical gain elements using physical effects such as giant magnetoresistance, buckling, electromechanical phase transitions, van der Waals forces, and Casimir forces to enable very low-noise, high-frequency amplifiers for low-power, low-noise analog signal processing. Possibilities of using mechanical power supplies and mechanical vibrating clocks could enable electronics that are less susceptible to electromagnetic pulse attacks. Enabling of nanomechanical elements in direct bandgap materials will circumvent problems of gate oxide stability, allowing fast logic with optics functionality. This program will transition into DoD systems via industrial program performers.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

(U) Program Plans:
FY 2007 Accomplishments:
– Developed nanomechanical switch-based logic in semiconductors, metals and insulators.
FY 2008 Plans:
– Develop mechanical gain elements for analog amplification using effects such as buckling and electromechnical phase changes.
FY 2009 Plans:
– Develop NEMS switches in direct bandgap materials to enable optical functionality with switches.

	FY 2007	FY 2008	FY 2009
Chip-Scale Auto Pilot	0.000	0.000	3.000

(U) The Chip-Scale Auto Pilot program will develop a new chip-scale subsystem for unmanned aerial vehicles (UAVs), which will provide on-board autonomous capabilities for collision avoidance and maneuvering support. The system will use data from miniature inertial sensors, imagers, and other sensors, and a data-fusion algorithm to produce control signals for the facilities on an existing UAV, such as the Wireless Application Service Provider (WASP). The goal is to allow operators of UAVs in dense urban environments to focus on high-level objectives, and to leave responsibility for survival and maneuvering to the UAV.

(U) Program Plans:
FY 2009 Plans:
– Develop mm-scale navigation system merging signals from Inertial Measurement Unit (IMU), Vision, GPS, and Timing.
– Fuse data from complimentary systems for on-board, autonomous collision avoidance and basic navigation functions.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

	FY 2007	FY 2008	FY 2009
Micropumps	0.000	0.000	3.000

(U) The Micropumps program will address the current need for chip-scale micropumps with significantly improved performance (~10^{-6} Torr and less than 1 cm^3 in volume). Microscale pumps have been developed by numerous research groups, but many microsystems still employ off-chip pumping because available microscale pumps do not meet application requirements. Pumping is crucial for distributing fluids through a microsystem and for providing a vacuum for various technologies, including micro mass spectrometers, nanoscale detectors, RF resonators, and a variety of other Nano MEMS devices. In many cases, the limiting factor in development of an integrated, low-power, micro total analysis system or electronic device is the pump. The goal of the Micropumps program is to provide improvements in microscale pumping capabilities to facilitate and greatly enhance operation of a variety of microsystems for DoD applications.

(U) Program Plans:
FY 2009 Plans:
- Demonstrate new microscale pump designs with high compression ratios.
- Demonstrate microscale pumps with high pump speeds and high vacuum levels.

	FY 2007	FY 2008	FY 2009
NanoCAD	0.000	0.000	3.000

(U) One of the key problems with nano electro-mechanical system (NEMS) and microelectromechanical systems (MEMS) component development is the time lag between device conception to manufacturing or even prototyping. This long development time is often due to the many number of iterations needed to make devices, which involve multiphysics domains. Furthermore, the cost of manufacturing tends to be determined in the future rather than in the beginning, as it is the case with other developed technologies like CMOS. The goal of the NanoCAD program is to reduce the time to market for MEMS and NEMS components.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

(U) Program Plans:
FY 2009 Plans:
- Develop natural graphic modeling techniques to take mechanical and electrical concepts and turn them into process flows.
- Develop reduced variable models that connect the nanoscale physics (e.g. contact physics, thermal and electrical conduction) to micro-scale to macro-scale physics on a PC workstation.
- Develop a simulation database from different working groups.

	FY 2007	FY 2008	FY 2009
Magnetic MEMS	0.000	0.000	3.000

(U) Recent breakthroughs in 3-dimensional (3-D) fabrication, including work on DARPA's 3-D Micro Electromagnetic Radio Frequency Survey (MERFS) program, as well as development of photo-patternable glasses, patternable ceramics, and other technologies have now opened up the potential of 3-D fabrication. This effort will explore the potential of using these new fabrication technologies to capture magnetic phenomenology and effect miniaturization and improved performance of a range of critical military systems.

(U) Program Plans:
FY 2009 Plans:
- Utilize 3-D fabrication technologies to demonstrate range of new high-performance 3-D magnetic components and systems.

	FY 2007	FY 2008	FY 2009
Chip-Scale Direct Sampling Receivers (CSDSR)	0.000	0.000	2.000

(U) The Chip-Scale Direct Sampling Receiver (CSDSR) program aims to realize true software-defined radio front-ends that feed RF input signals directly to analog-to-digital converters (ADC's), allowing the rest of the radio to be realized digitally and completely reconfigurable via software. The key to making this possible is the use of technologies capable of isolating channels (not bands, but channels with <0.05% bandwidth) directly after the antenna, removing all out-of-*channel* interferers before they arrive at the low noise amplifier (LNA)/ADC input,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

hence substantially relaxing the dynamic range required by the LNA/ADC to achieve a given receiver jam-resistance. In essence, the removal of all interferers by the channelizer allows the ADC to operate without the need to reject strong interferers, thereby without the need for a high dynamic range. This allows the use of fewer bits, making it possible for the ADC to handle GHz input frequencies without excessive power consumption. The CSDSR program would ultimately make possible universal receivers capable of operating under conceivably any communication standard by merely reconfiguring itself.

(U) Program Plans:
FY 2009 Plans:
- Demonstrate software-defined radio functions.
- Demonstrate an array of nanomechanical resonators for software-defined communications and jam-resistant applications.

	FY 2007	FY 2008	FY 2009
Micromechanical Amplifiers	0.000	0.000	3.000

(U) The Micromechanical Amplifiers program will realize micromechanical circuits that amplify signals (e.g., for communications, sensing, etc.) with substantially better efficiency, lower noise, and higher dynamic range, than currently achievable via state-of-the-art electronic implementations.

(U) Program Plans:
FY 2009 Plans:
- Demonstrate and optimize new approach for resonant switch-based mechanical amplifier.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

	FY 2007	FY 2008	FY 2009
Chip-Scale High Energy Atomic Beams	0.000	0.000	3.000

(U) The Chip-Scale High Energy Atomic Beams program will develop chip-scale high-energy atomic beam technology by developing high-efficiency radio frequency (RF) accelerators, either linear or circular, that can achieve energies of protons and other ions up to a few mega electron volts (MeV). Chip-scale integration offers precise, micro actuators and high electric field generation at modest power levels that will enable several order of magnitude decreases in the volume needed to accelerate the ions. Furthermore, thermal isolation techniques will enable high efficiency beam to power converters, perhaps making chipscale self-sustained fusion possible.

(U) Program Plans:
FY 2009 Plans:
- Develop 0.5 MeV proton beams and collide onto microscale B-11 target with a fusion Q (energy ratio) > 20, possibly leading to self-sustained fusion.
- Develop neutron-less fusion allowing safe deployment for handheld power sources.
- Develop microscale isotope production by proton beam interaction with specific targets.
- Explore purification of isotope systems.
- Develop hand-held pico-second laser systems to introduce wakefield accelerators for x-ray and fusion sources.

	FY 2007	FY 2008	FY 2009
Microtechnologies for Air-Cooled Exchangers (MACE) Heat Sink Enhancement	0.000	0.000	3.000

(U) The Microtechnologies for Air-Cooled Exchangers (MACE) Heat Sink Enhancement program will explore emerging concepts for enhancement of the performance of heat rejection systems throughout the DoD. Specific program goals include the reduction of the thermal resistance by a factor of 4x and reducing the power consumption of the cooling system by 3x. Successful projects will apply MACE technologies to a customer-specified application.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

(U) Program Plans:
FY 2009 Plans:
- Demonstrate models, measurements, and Single-Fin device.
- Establish functional full-scale heat sink 4”x4”x1” with 4x reduction in thermal resistance and 3x improvement in coefficient of performance.

	FY 2007	FY 2008	FY 2009
Small Scale Systems Packaging	1.100	0.000	0.000

(U) The Small Scale Systems Packaging program developed small-scale electronics packaging technology for more efficient microelectronics manufacturing.

(U) Program Plans:
FY 2007 Accomplishments:
- Developed advanced roll-to-roll manufacturing processes for microelectronics.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE February 2008		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15				
COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Mixed Technology Integration MT-15	127.187	157.972	144.089	134.826	123.133	122.697	122.696

(U) Mission Description:

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

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

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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

technologies onto a single substrate will drive down the size, weight, volume, and cost of weapon systems while increasing their performance and reliability.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Adaptive Photonic Phased Locked Elements (APPLE)	11.300	10.521	9.792

(U) The goal of the Adaptive Photonic Phased Locked Elements (APPLE) program is to demonstrate a fully scalable and modular architecture of phased sub-apertures capable of producing an arbitrarily large optical aperture that can be rapidly and non-mechanically steered over a wide field of regard with high precision. This effort is anticipated to transition via industry for potential laser systems and space based applications.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated a small (25 millimeter diameter) single aperture that can handle a low level of input laser power (50 Watts) and was able to support an initial demonstration of a controlled combination of outputs from multiple apertures.

FY 2008 Plans:

- Demonstrate the controlled combining of the outputs of multiple (7) small individual apertures at low input powers.
- Demonstrate a small single aperture that can handle a high level of input laser power (200 Watts).

FY 2009 Plans:

- Demonstrate high power combined output of multiple (7) small individual apertures.
- Demonstrate atmospheric compensation in the real atmosphere at low powers.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
Data in Optical Domain Network (DoD-Network)	9.299	7.200	7.851

(U) Currently, optical networks use photonics to transport data and electronics to process data. However, as the underlying bit rates of the optical networks are pushed beyond 40 giga-bits per second there will be significant processing bottlenecks in these networks and these bottlenecks will severely limit the military's ability to rapidly transport time critical information. A potential solution to this problem is to develop photonic technology so optics can take over higher order network processing functions. The DoD-Network program will develop and demonstrate four key photonic technologies to meet these challenges: all-optical routing, all-optical data buffering (controllable and eventually random access), optical logic and circuits, and all-optical (multi-wavelength) regenerators. These photonic technologies will lead to intelligent all-optical networks. The program will have two major areas of interest: the first will focus on developing new photonic technology that is essential if photonics is to play a significant role in higher order processing in optical networks, the second area will focus on developing novel architectures that will fully exploit the new photonic technology to bring new and increased functionalities to the optical networks. The DoD-Network program is anticipated to transition via industry to high speed, high capacity optical networking programs of interest to the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated that small buffers (achievable in the optical domain) have minimal impact on the network performance when the network traffic consists of a large number of simultaneous unsynchronized Transmission Control Protocol flows.
- Demonstrated all optical and hybrid clock recovery.

FY 2008 Plans:

- Demonstrate all-optical, Indium Phosphide (InP)-based, integrated photonic, packet forwarding chip which supports forwarding and re-labeling of optical packet headers.
- Demonstrate the first fully monolithic separate absorption and modulation wavelength converter operating "error-free".

FY 2009 Plans:

- Develop an all-optical data router with high data rate ports.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
Microantenna Array Technology & Applications (MIATA)	2.275	1.821	2.000

(U) The goal of the Microantenna Array Technology & Applications (MIATA) program is to develop low-cost arrays that can sense both Millimeter Wave (MMW) and IR scenes along with compact MMW designator sources for passive and active imaging applications in the spectral region from W-band (94 GHz) to the long wave infrared optical region. New micro- and nano-fabrication techniques of low cost antenna arrays provide a basis for revolutionary tactical military applications in the unexploited submillimeter to long wave optical spectral region. The military utility of this technology includes conventional passive imaging with compact devices at elevated temperatures, passive or active ballistic imaging through extreme weather and obscurants, polarization discrimination of manmade objects, rapid electronic spectral tuning for clutter discrimination, ultra-wide band response (achieved using metal-insulator-metal tunneling structures for sensing/rectifying the antenna current), and may also include synthetic apertures, phased arrays, true time, and steered receiver beams. The resulting MMW cameras will be lighter, cheaper, and have a higher performance than conventional cameras. The improved MIATA diodes will have low-gain low-noise amplifiers (LNAs) integrated on the focal plane. Applications include imagers for concealed weapon detection and helicopter landings in brownout. The MIATA program is planned for transition to the Army Research Laboratory at the conclusion of Phase III, which is anticipated to be completed in FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Achieved 95 gigahertz (GHZ): Noise Equivalent Temperature Detection (NETD) $\leq$ 20 Kelvin (K) in a 2x2 array.
- Achieved 8-12 um: NETD $\leq$ 0.1 K in an 8x8 array.

FY 2008 Plans:

- Achieve 95 GHZ: NETD $\leq$ 2 K in an 8x8 array.

FY 2009 Plans:

- Achieve 8-12 um: NETD $\leq$ 0.02 K in a 64x64 array.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
Ultra-Wide Band Technology	5.500	10.500	0.000

(U) Radar array antennas that use the Ultra-Wide Band Technology hold the promise of a new class of high coverage/high sensitivity systems. DARPA is tackling the issue through Ultra-Wide Band Multi-Function Photonic Transmit and Receive (ULTRA T/R) Modules.

(U) The objective of the ULTRA T/R program is to develop a wideband microwave antenna interface and corresponding antenna elements that would replace the conventional electronic T/R module-antenna combination and offer multiple modes of operation (e.g. simultaneous transmit and receive or switched mode), fiber interface to/from either digital or analog beamformer at significantly reduced size, weight, and power. The ULTRA T/R program is planned for transition to Navy and Air Force Airborne Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C^4ISR) platforms and wide band phased-array antenna systems at the conclusion of Phase III, which is anticipated to be completed by FY 2008.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed and demonstrated optical modulators, which exhibit low switching voltages and incorporate a long effective electrode length.
- Demonstrated > +27 decibel milliwatt radio frequency power handling in a single photodiode at 6 gigahertz.

FY 2008 Plans:

- Demonstrate > 40 decibels transmit/receive isolation in a photonic circulator over a larger bandwidth in the X-band.
- Demonstrate photodiodes with 3rd order output intercept points higher than state-of-art.
- Demonstrate a photonic circulator with world record gain and low noise figure in the receive mode and with improved transmit/receive isolation over a large bandwidth in the X-band.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
Laser-Photoacoustic Spectroscopy (L-PAS)	5.238	0.000	0.000

(U) The Laser-Photoacoustic Spectroscopy (L-PAS) program developed and demonstrated highly sensitive, compact, rapid, reliable, inexpensive, and low power consuming chemical agent sensors based on the principle of laser photoacoustic spectroscopy. The L-PAS sensor discriminated a wide variety of possible chemical agents, explosives, and narcotics in the presence of diverse background environments. L-PAS transitioned prototype chemical agent sensors to the Joint Science and Technology Office (JSTO), Defense Threat Reduction Agency for evaluation. To that end, JSTO and DARPA worked closely to ensure that the final program addressed the joint Chemical/Biological community needs.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated working prototypes that have a sensitivity to <1 part per billion (ppb) at a false alarm rate of better than 10^{-6}.
- Demonstrated a major improvement in performance (measured in terms of sensitivity) over the Joint Chemical Agent Detector system, which is the next generation chemical sensor currently under development.
- Developed tuned lasers with a range of $\pm$ 40 nanometers (nm).
- Fabricated infrared micro-photonics.
- Assembled complete quantum laser diode modules with mid- and long- wave IR ranges.
- Developed tunable Quantum Cascade Lasers with resonant acoustic chamber detection cell.

	FY 2007	FY 2008	FY 2009
High Operating Temperature - Mid-Wave Infrared (HOT MWIR)	8.870	19.405	0.000

(U) The objective of the High Operating Temperature - Mid-Wave Infrared (HOT MWIR) program is to establish technology for high-speed sampling and high spatial resolution infrared focal plane arrays that operate in the mid-wave infrared without cryogenic cooling. The high sampling speed is required for both threat detection and for imaging from fast moving platforms. Technology goals are to achieve greater than an

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

order of magnitude reduction in currents contributing to detector noise demonstrated with a high density, large area detector array format of up to 1280 x 720 elements. For imaging, the sensor will respond in a broad spectral band, including the mid and long wave infrared, and will be optimized for imaging at high frame rates with large field of view. This program is anticipated to transition via industry for applications such as multi-band mid-wave or micro-detectors.

(U) Program Plans:

FY 2007 Accomplishments:

- Designed new approaches necessary to reduce detector dark current and noise.
- Amplified the low-level signal in multi-band mid wave detectors, showing potential for high sensitivity and fast response in room temperature arrays.
- Developed micro-detectors, which collect signals from a large area while reducing the volume available for detector noise generation.
- Demonstrated carrier extraction techniques in the laboratory to show potential to reduce excess current while maintaining high-speed signal levels.

FY 2008 Plans:

- Demonstrate 256x256 arrays operating at 250 kelvin with X8 – X10 lower dark current.
- Establish pixel design and test arrays for mega-pixel room temperature arrays.
- Demonstrate high density arrays with dual band (Mid/Long Wavelength Infrared) response.

	FY 2007	FY 2008	FY 2009
Visible/Short Wave IR - Photon Counting	3.880	5.297	5.004

(U) The Visible/Short Wave IR - Photon Counting program will develop imaging over a broad spectral band at extremely low levels of ambient illumination to provide a unique capability for remote sensing, unattended sensors, and pay-loads for autonomous ground and air platforms. Recent innovations in solid state imaging devices, including parallel processing at the pixel level and novel read read-out technology, can contribute to development of a new class of sensors, which can create an image with only a few photons per pixel, exceeding performance of current low light level imagers. The direct conversion of low light level information into an electronic format provides access to a suite of signal

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

processing, image enhancement and communications techniques not available with current low light level imaging devices. This program will transition via industry for ultraviolet to infrared imaging applications.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed unique electronic read-outs with internal gain that boost low level signals above output amplifier noise.
- Developed potential approaches to include distributed amplification in the read-out signal chain, avalanche multiplier gain internal to the pixel.
- Reduced short wave infrared detector dark current, resulting in lower power man-portable imaging sensors.

FY 2008 Plans:

- Demonstrate read-out integrated circuit for short wave infrared with less than 10 noise electrons.

FY 2009 Plans:

- Integrate low noise focal plane array into a mega-pixel array format and demonstrate room temperature imaging.
- Demonstrate single photon counting devices for ultra low noise imaging.

	FY 2007	FY 2008	FY 2009
Electronic & Photonic Integrated Circuits on Silicon (EPIC)	12.548	5.223	0.000

(U) The Electronic & Photonic Integrated Circuits on Silicon (EPIC) program will develop two critical alternative photonic technologies based on silicon substrates. The first thrust addresses active photonic components based on silicon, which do not rely on generating light within the material. While passive photonic components, such as waveguides, can be fabricated from silicon, silicon's indirect bandgap does not lend itself to fabricating active photonic components based on the generation of photons (lasers, amplifiers etc.). The first alternative technology development will be optical amplifiers using Raman gain. Fiber amplifiers based on Raman gain currently play a major role in optical networks, and demonstrating this optical amplification in silicon will be a major step toward overcoming on-chip losses in complex chip-scale optical components. The second alternative technology development will address optical transistor action, or switching, in silicon (i.e., a three-terminal optical device in which control photons at one terminal will make a large change in the photons transmitted between the other two terminals). Taken together, these two capabilities will create a new paradigm in which silicon will provide a platform for monolithic integration of photonic

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

and electronic functions. The EPIC program is anticipated to transition via industry to optical communication and electronic warfare programs of interest to all Services.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed process for integration of germanium-based photodetectors with an integrated amplifier in foundry-compatible complementary metal-oxide-semiconductor process.
- Demonstrated optically-implemented microwave-frequency nulling filter to drop unwanted channels.

FY 2008 Plans:

- Demonstrate 40 gigabytes per second capacity transceiver chip with four wavelengths.
- Demonstrate a wideband radio frequency channelizer with multiple channels and nulling of at least a single channel.
- Increase integration complexity of electronics and photonics to include hundreds of photonics components.

	FY 2007	FY 2008	FY 2009
Space, Time Adaptive Processing (STAP) BOY	4.899	4.240	1.000

(U) The Space, Time Adaptive Processing (STAP) BOY program will research, develop, and demonstrate miniature, low-power, low-cost, teraflop-level signal processing solutions derived from commercial Graphics Processor Unit (GPU) hardware and software of the type currently used for fast geometry computations in hand-held electronic games like Nintendo's GAME BOY®. Success in this program will allow the DoD to exploit the continuing phenomenal growth in both performance and programmability of GPUs resulting from competition in the multi-billion dollar international electronic entertainment industry. Particularly relevant advantages of recent GPUs over more traditional embedded processors include enhanced memory access bandwidth, hardware-accelerated floating-point vector geometry functions, low power consumption, and open source programming language support. The STAP BOY technology is planned for transition to the Army at the conclusion of Phase III, which is anticipated to be completed in FY 2009.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:

FY 2007 Accomplishments:

– Developed and characterized a prototype architecture using a single GPU and a Field Programmable Gate Array input-output structure.

FY 2008 Plans:

– Demonstrate that the prototype system is capable of sustaining 100 giga floating point operations per second (Gflops) potentially scalable to a multi-GPU pipeline mesh teraflop computing architecture, and is easily programmable to provide extremely high performance in diverse challenge problems.

FY 2009 Plans:

– Demonstrate the single GPU prototype consisting of 1) adaptive algorithm for data structure simplification, suitable for adaptive weight computations in STAP and 2) 3-D tomographic reconstruction processing for aperture synthesis.

	FY 2007	FY 2008	FY 2009
Vertically Integrated Sensor Arrays (VISA)	3.000	6.713	0.000

(U) The Vertically Interconnected Sensor Arrays (VISA) program will develop and demonstrate vertically interconnected, focal plane array read-out technology capable of more than 20-bits of dynamic range, over an order-of-magnitude higher than current state-of-the-art, enabling significant advances in the functionality of infrared systems. Vertical interconnections between the detectors and the read-outs that avoid first going through row-column multiplexers will allow for high frame rates concurrent with high-resolution images.

(U) The program will expand architectures for three-dimensional focal plane arrays, where multiple levels of signal processing are integrated into each pixel in the array, to include multiple processing layers, higher density vias (small openings in an insulating oxide layer that enable electrical connections, e.g., between layers) at the pixel, and coverage of a broad spectral band from the visible to the infrared. This increased on-chip processing power will enable new capability for smart sensors, such as high-speed imaging, on-chip threat discrimination, and anti-jamming. Defense applications include mid-/long-wavelength target acquisition systems for air and ground, smart missile seekers, anti-jamming, and imaging through high intensity sources. This effort will transition through the current VISA industrial performers into a wide range of military imaging systems including the capability to image targets in low contrast, high clutter, or low light scenes such as a low signature cruise missile against sun-glint from the ocean.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated high dynamic range imaging sensors with an analog to digital converter at each pixel in the array.
- Designed and developed three-dimensional focal plane architectures with multiple levels of signal processing at each detector in the array.

FY 2008 Plans:

- Develop thru-via and interconnection technology with greater than 99% operability on 256x256 arrays.
- Perform imaging showing temperature gradients in object at a high temperature, demonstrating capability of high dynamic range.
- Demonstrate wafer bonded interconnect showing feasibility of high-density pixel arrays, beyond current indium bump interconnect technology.
- Demonstrate feasibility of high-density vias to increase circuit area available for processing.
- Develop advanced vertically integrated sensor architecture with capability to integrate high dynamic range into high density pixel.

	FY 2007	FY 2008	FY 2009
Analog Spectral Processors (ASP)	4.500	13.483	13.877

(U) The Analog Spectral Processors (ASP) program will leverage existing MEMS capabilities to make precision RF components, and perform low-insertion-loss/heterogeneous components integration to demonstrate integrated Analog Spectral Processors that greatly reduce dynamic range and bandwidth required on analog/digital converters and other front-end components. This will enable proliferation of advanced RF capabilities to the individual war fighter by dramatic reduction in size, weight, and power of RF systems. Industrial firms that are currently the major suppliers of radio equipment for defense and homeland security applications will serve as the primary transition partners upon successful completion of the program.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed design and modeling of novel front-end architecture, and derived specifications for filter and switch components.
- Developed and tested novel filter and switch components operating from 20 megahertz (MHz) – 6 gigahertz (GHz).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

– Conducted independent verification of component performance.
– Completed Preliminary Design Review utilizing filter results to demonstrate component feasibility.

FY 2008 Plans:

– Demonstrate intimate integration of filter and switch components.
– Demonstrate pre-selector, intermediate frequency, and analog filter sensor banks.
– Complete Conceptual Design Review.

FY 2009 Plans:

– Integrate filter banks with active components.
– Demonstrate complete front end meeting size, power, and performance objectives.

	FY 2007	FY 2008	FY 2009
Electromagnetic Pulse Tolerant Microwave Receiver Front End (EMPIRE)*	5.525	5.100	5.690

*Formerly titled All-Dielectric Non Electronic RF Front-End (ADNERF).

(U) The Electromagnetic Pulse Tolerant Microwave Receiver Front End (EMPIRE) program will create a wide bandwidth, tunable RF front end technology that is immune to electromagnetic pulse (EMP) attack. This program will seek an entirely new approach to RF front-end technology where all metal and front-end electronic circuitry are eliminated. Of particular interest will be an all-dielectric, electronics-free RF front end with sensitivity and dynamic range consistent with today's wireless communication and radar systems. By eliminating the metallic antenna, a secondary goal is to effect a significant reduction in detectable radar cross section.

(U) EMPIRE represents the ultimate solution for protecting wireless communication and radar systems. EMPIRE can find immediate application protecting tactical communication and radar systems, which are highly vulnerable to EMP attack due to their close proximity to enemy assets. As the efficiency and tunability of the all-dielectric non-electronics front-ends improve, the technology can become an ubiquitous RF front end for all military as well as commercial wireless devices, providing the communications infrastructure immunity against EMP attacks. This program will transition through industry performers involved with reducing the susceptibility of electronics to damage from high electro-magnetic pulse weapons.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:

FY 2007 Accomplishments:

– Identified and developed innovative dielectric materials with high dielectric constant and low loss.

FY 2008 Plans:

– Design and implement doubly resonant (RF and optical) antenna structures in support of non-electronic signal transduction.

FY 2009 Plans:

– Demonstrate dramatic reduction in RF front-end susceptibility to electromagnetic pulses while maintaining militarily useful system.

	FY 2007	FY 2008	FY 2009
Microsensors for Imaging (MISI)*	3.757	3.920	4.917

*Formerly titled High Gain Optical Transceiver on a Chip.

(U) The Microsensors for Imaging (MISI) program establishes technology for extremely small, lightweight cameras sensitive in the short wave infrared for a wide range of applications. MISI is initially focused on two important areas, micro-air vehicles and a head-mounted system. The camera components comprise a micro-system including optics, focal plane array and electronics with display, energy source and illuminator included as the head-mounted system. The limitation of weight and power places demands on the sensor technology for exceptional image quality in a micro-package. This technology will have many DoD applications. In the micro-air vehicle application, the weight goal is ten (10) grams, (including the optics, detector and electronics) for a camera with a degree field of view and recognition range of one-hundred meters. In the head-mount application, the weight goal of three-hundred fifty (350) grams includes the sensor with display and power source. This program will transition through industry performers into DoD systems, allowing integration into small robotic platforms and micro-air vehicles.

(U) Program Plans:

FY 2007 Accomplishments:

– Completed array and integrated package design to achieve microsensor in extremely small package suitable for microvehicle applications.

– Completed design to demonstrate stable device operation over a wide temperature range.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

FY 2008 Plans:
- Demonstrate imaging arrays in micropackage for both man-portable and micro-vehicle applications, with package thermal stability for long-lifetime operation.
- Complete design of short wave arrays for helmet mounted applications compatible with illuminator and compact system design.

FY 2009 Plans:
- Demonstrate megapixel arrays in micropackage that amplify low level optical signals with minimum excess noise while maintaining uniformity across the array.
- Demonstrate operation at room temperature over military temperature range.

	FY 2007	FY 2008	FY 2009
Maskless Direct-Write Nanolithography for Defense Applications	19.000	22.600	20.100

(U) The Maskless Direct-Write Nanolithography for Defense Applications program will develop a maskless, direct-write lithography tool that will address both the DoD's need for affordable, high performance, low volume Integrated Circuits (ICs) and the commercial market's need for highly customized, application-specific ICs. In addition, this program will provide a cost effective manufacturing technology for low volume nanoelectromechanical systems (NEMS) and nanophotonics initiatives within the DoD. Transition will be achieved by maskless lithography tools, installed in the Trusted Foundry and in commercial foundries, which will enable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems.

(U) Program Plans:

FY 2007 Accomplishments:
- Completed and delivered End-to-End System Error Budget and throughput model.

FY 2008 Plans:
- Design, build and integrate a demagnification optics system and wafer adapter, and achieve a patterning resolution on the wafer of about 1 micron.
- Characterize prototype Reflection Electron Branch Lithography (REBL) system to validate simulation results.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

FY 2009 Plans:
- Demonstrate rotary stage at 10 meters per second.
- Demonstrate static imaging on prototype REBL system.
- Demonstrate dynamic imaging on prototype REBL system.

	FY 2007	FY 2008	FY 2009
Stand-off Solid Penetrating Imaging*	3.058	3.942	5.900

*Formerly titled Stand-off Detection and Identification.

(U) The Stand-off Solid Penetrating Imaging program will detect and identify explosive threats at a stand-off distance, a critical requirement for force protection in all military operations, especially in urban scenarios. Multiple techniques will be available for detection, but no single technique provides both high probability of detection with low false alarm rate, and identification of specific characteristics of the threat. A micro-system approach with multiple, synergistic sensor technologies integrated in a compact package will be critical to wide spread deployment of this sensor capability.

(U) The microsystem approach involves the identification of significant attributes from multiple non-over-lapping perspectives, such as shape and chemical signature, at stand-off ranges of fifty meters to potentially one hundred meters. This presents major challenges in imaging through opaque media, identifying signatures in parts per billion in high background ambient, selecting specific wavelength bands of interest, and the signal/imaging processing required for positive identification. The system configuration presents additional integration challenges for potential application in manportable systems or small autonomous vehicles. This program will transition through industry performers into DoD systems aimed at developing stand-off X-ray imaging devices for robotic vehicles. This program will allow X-ray imaging at a distance of up to 50 meters.

(U) Program Plans:

FY 2007 Accomplishments:
- Demonstrated in the laboratory unique image reconstruction techniques suited to imaging through visually opaque objects at a 50 – 100 meter stand-off distance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

FY 2008 Plans:
- Assess X-ray source requirements, such as power, size, weight, focal spot, and tube configuration including various beam formation techniques.
- Implement X-ray imaging reconstruction for remote vehicle applications.

FY 2009 Plans:
- Trade-off source requirements for more efficient sensor technology, notably two-dimensional arrays of cadmium telluride or silicon carbide with high spatial resolution.
- Demonstrate X-ray image at 50 – 100 meters, and address issues including efficient radiation coupling into the sensor, spectral selectivity, and signal enhancement techniques.

	FY 2007	FY 2008	FY 2009
Deep Ultraviolet Avalanche Photodetectors (DUVAP)	3.500	3.171	2.434

(U) Recent advances in Wide-Bandgap Semiconductor materials have opened new possibilities for exploiting the ultra-violet (UV) region of the electromagnetic spectrum. The current Deep Ultraviolet Avalanche Photodetectors (DUVAP) program has been successful in advancing the state of the art of UV light emitting diodes and laser diodes. This follow-on program seeks to develop high sensitivity, compact UV detectors. Specifically, avalanche photodiodes (APDs) will be developed to detect single photons. These UV detectors will dramatically improve the performance and reduce the size and weight of the biological warning detectors under development in the DUVAP program. They will also increase the range and data rate of covert UV communications systems. This program will transition through industry and university performers developing compact, reliable, and cost-effective photodetectors for a variety of military applications.

(U) Program Plans:

FY 2007 Accomplishments:
- Demonstrated Geiger mode operation at 280 nanometers.
- Determined maximum defect density for stable avalanche gain.
- Demonstrated solar blind UV filter compatible with the APD structure.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

FY 2008 Plans:
- Develop Optimized Geiger mode device.
- Optimize E Materials for low defect density and reproducibly high device yield.
- Demonstrate Solar-blind UV filter with on/off cutoff of 103, integrated with a discrete device.

FY 2009 Plans:
- Demonstrate 1 cm^2 array of Geiger mode APDs with dark count rate <10 kHz and solar rejection ratio of 106.

	FY 2007	FY 2008	FY 2009
WIFI-EYEPOD	0.000	3.492	6.000

(U) The WIFI-EYEPOD program will transform the dismounted soldier into a semi-autonomous direct current (DC) - 10 GHz sensor/comms/signals intelligence platform using a personal digital assistant (PDA) modified with a broadband multifunctional RF sensor plugged into its Universal Serial Bus (USB) port. Combined with the current DARPA STAP BOY program, or even a standard laptop, the RF-EYEPOD enhancement will enable real-time local processing for extremely time-sensitive and perishable data requiring immediate processing and response. The WIFI-EYEPOD RF sensor may be used to control and or hunt near field enemy WIFI and communications networks allowing the soldier to virtually see enemy combatants communicating and setting up attacks, hiding behind walls and in buildings mixed with non-combatants. Working in small networks will permit instantaneous location(s) of sniper fire and gunfire for retribution, and positions of tactical squad members relative to inside and outside of buildings, without detection by enemy sensors.

(U) In addition to adding RF-sensory and networking capability to PDAs and vehicle-mounted information processing hardware, the WIFI-EYEPOD will provide secure communications and networking capability so that the processed information can be compressed and downloaded real-time to larger, holistic sensor integration systems, providing micro-detail to create macro understanding at the unit and division command levels. Transition targets are through Army PM Soldiers Systems and USMC ground forces.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:

FY 2008 Plans:

- Develop, integrate and optimize diverse system capabilities into a single low cost miniature package with a cost target at less than $1 thousand per unit.
- Optimize commercial integrated circuits in wideband digital synthesizers, and custom high dynamic range Analog/Digital Converters and digital filters into a mixed-signal Analog Signal Integrated Circuits using the latest processes in silicon-germanium (SiGe) and 90nm complementary metal-oxide-semiconductor.

FY 2009 Plans:

- Integrate a modem, quad-band antenna, and Ultra-Wide Band antenna and transmitter with commercial interface to create an embedded processing unit.

	FY 2007	FY 2008	FY 2009
Airplane on a Chip (AOC) - Chip Scale Avionics	0.000	0.000	2.000

(U) The Airplane-on-a-Chip (AOC) - Chip Scale Avionics program seeks to exploit continued advances in integrated Microsystems technology to remake the stovepipe/legacy avionics architecture which are present in modern aircraft. The fundamental goal of the program is to deliver an avionics system approaching one cubic centimeter in volume and dissipating 10s of milliwatts of power, compared with 10s of cubic centimeters (best case) and 10s of Watts of power in contemporary systems. The program will bring together advances in Chip Scale Atomic Clocks, Navigation Grade Integrated Micro Gyroscopes, 3-Dimensional Electronics, Compressive Sensing, Chip Scale Wavelength Division Multiplexing, and Robust Integrated Power Sources, to name only a few, to revolutionize avionics for the 21st century. It is expected that such advances will revolutionize airframe design and capability by delivering more functionality at lower power in a smaller volume, enabling distributed avionics for enhanced survivability and increase autonomous operation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:
FY 2009 Plans:
- Develop advanced integrated microsystems technologies for avionics guidance, navigation, and control that exploit progress in Chip Scale Atomic Clocks, Navigation Grade Integrated Micro Gyroscopes, 3-Dimensional Electronics, Compressive Sensing, Chip Scale Wavelength Division Multiplexing, and Robust Integrated Power Sources programs.
- Deliver an avionics system approaching one cubic centimeter in volume with power dissipation on the order of tens of milliwatts.

	FY 2007	FY 2008	FY 2009
Ultradense Nanophotonic Intrachip Communication (UNIC)*	9.486	5.500	10.950

*Formerly titled Nanophotonics for Ultradense On-chip Communications.

(U) The goal of the Ultradense Nanophotonic Intrachip Communication (UNIC) program is to demonstrate nanophotonic technology for (1) access to on-chip ultra-dense systems and (2) Input/Output (I/O) to/from a chip containing such ultra-dense systems. Technical challenges that must be met include: high precision, low loss nanophotonic circuit fabrication, low cost fabrication methods, high performance nanoscale modulators, detectors, multiplexers and demultiplexers, architecture for addressing ultra-dense systems, techniques for efficient high capacity/bandwidth I/O of data to and from the chip. This technology will transition via industrial performers developing ever faster and more complex processing such as real-time pattern matching, target recognition, image processing and THz class command-and-control networks.

(U) Program Plans:
FY 2007 Accomplishments:
- Initiated high performance, low power active and passive photonics at ~ 1 mm size-scale for on-chip global interconnects for significantly improved processor performance.

FY 2008 Plans:
- Create novel designs to demonstrate extremely low power complementary metal-oxide-semiconductor (CMOS) compatible silicon photonic devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

FY 2009 Plans:

– Demonstrate extremely low power CMOS-compatible silicon photonic devices that demonstrate a path to on-chip optical communication links that are superior to conventional electronic messaging in single-die multiprocessor computing architectures.

	FY 2007	FY 2008	FY 2009
Hemispherical Array Detector for Imaging (HARDI)	4.744	3.486	4.682

(U) The objective of the Hemispherical Array Detector for Imaging (HARDI) program is to exploit the benefits of the hemispherical imaging surface. The basic idea behind the program is that a detector array can be fabricated on a hemispherical substrate using materials such as organic/inorganic semiconductors and that this array can be combined with a single lens to produce a wide field of view, small form factor camera. Organic materials have been shown to have good electronic and optoelectronic properties including light emission and detection. Furthermore, in-plane organic/inorganic transistors can be incorporated for pre-processing of images. This program will transition to eventual DoD systems through a demonstration of an array prototype developed by industrial contractors.

(U) Program Plans:

FY 2007 Accomplishments:

– Demonstrated a manufacturing process for fabrication on hemispherical surface and developed high detectivity materials over broad wavelength range.

FY 2008 Plans:

– Develop high efficiency detector materials.
– Demonstrate curved single pixel detector.

FY 2009 Plans:

– Develop improved materials for Visable-Near IR-Shortwave IR (VIS-NIR-SWIR).
– Demonstrate a curved focal plane array.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
Day/Night Adaptive Imager	0.000	3.000	5.000

(U) Low light level imaging has proven its value by providing the individual warfighter with the tactical advantage to see first in crucial night imaging scenarios. With widespread use of low light level technology, a new paradigm in low light level imaging is necessary to maintain these distinct advantages and provide new capability beyond current imaging technology. The new approach will incorporate noiseless detection and processing of individual photon events to leverage the benefits of solid state imaging and take advantage of three dimensional signal processing architecture at the detector. By detecting an image formed from individual photon events without the addition of excess noise, the image can be processed and manipulated to provide the user image information not possible with current sensors. This technology will transition through industrial performers into eventual systems for sniper scope devices and electronic imaging sensors for micro-air vehicles.

(U) Programs Plans:

FY 2008 Plans:

– Develop ultra-wide dynamic range imaging sensors that count individual photon events and also operate in high light level.

FY 2009 Plans:

– Reduce dark counts for room temperature operation.

– Demonstrate integrated functions, such as day/night imaging with covert signal detection.

	FY 2007	FY 2008	FY 2009
Miniature, Room Temperature, Ultra-sensitive Magnetic Sensor (MRUMS)	0.000	3.500	6.500

(U) The goal of this effort is to develop a micron scale, room temperature magnetic sensor with detection sensitivity at least comparable to that of a Superconducting Quantum Interference Device (SQUID). The device would also require low power and be produced with standard micro-fabrication processes. Recent work in organic materials that preserve electron spin coherence over tens to hundreds of nanometers and also in atomtronics suggest that room temperature ultra sensitive magnetic sensors are achievable. This technology will transition into DoD systems via industry.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:
FY 2008 Plans:
– Demonstrate proof of concept of compact single room temperature sensor for magnetic field.
FY 2009 Plans:
– Demonstrate high sensitivity compact single room temperature sensor for magnetic field.

	FY 2007	FY 2008	FY 2009
Contiguous Multi-Mega-pixel Infrared Imaging Arrays	0.000	3.000	5.000

(U) The Contiguous Multi-Mega-pixel Infrared Imaging Arrays program will address the development of large arrays for persistent surveillance with the objective of developing technology for multi-mega-pixel pixel arrays with integral signal and image processing. Since contiguous coverage over large areas is essential, approaches will be developed to construct extremely large array assemblies from smaller arrays without loss of lines at the intersection between arrays. A new array architecture will be designed to integrate electronic overhead functions, such as synchronization clocks, power bias lines and ground connections in a three dimensional structure directly under the active pixel array. This design leverages and extends the emerging three-dimensional signal processing technology and establishes a technology base for large contiguous array assemblies, not possible with current infrared arrays. Approaches also will be developed for the assembly of multiple infrared arrays on non-planar surfaces in order to realize practical optical designs for large arrays. This technology will transition via industry.

(U) Program Plans:
FY 2008 Plans:
– Develop approaches for contiguous butting of large infrared arrays without line loss at array intersection.
FY 2009 Plans:
– Demonstrate large arrays with integral data pre-screening to highlight potential targets and areas of interest.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
High Resolution Short Wave Infrared/High Density Infrared Retina	0.000	4.000	7.000

(U) The High Resolution Short Wave Infrared/High Density Infrared Retina program will address emerging material growth and deposition technology with the potential to produce extremely high resolution, high density short wave detector arrays. Growth approaches to be investigated include infrared quantum dots, which can be deposited directly from a solution, molecular beam epitaxy, and epitaxial growth onto selected areas of the silicon read-out. The growth techniques must be optimized to produce films with high optical absorption, and uniform film characteristics consistent with deposition over large areas. Electrical contact to small size detector elements also will be addressed. Approaches must be developed to form the electrical contact between small area detectors and input to low noise preamplifiers on the silicon substrates. This program is directed at reducing pixel size to the dimension of the wavelength, in the shortwave infrared (SWIR), mid-wave infrared (MWIR) and long-wave infrared (LWIR). The SWIR is the most demanding case since the wavelength is the shortest. This technology will transition into eventual DoD systems through program industrial performers.

(U) Program Plans:

FY 2008 Plans:

- Develop material growth and array processing for extremely high-resolution short wave infrared with pixel size on the order of the wavelength.

FY 2009 Plans:

- Develop new detector approaches for high pixel density with passivation processes to control surface leakage, which will dominate small detectors.
- Demonstrate test structures with detector size approaching two microns and show contact method to small pixel structure.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
Control of Optical Properties of Infrared Semiconductors	0.000	3.250	5.000

(U) The Control of Optical Properties of Infrared Semiconductors program seeks to electronically control the optical emission from infrared semiconductor material in infrared material and devices with pay-off in several new areas important to defense systems. The equilibrium level of electronic charge carriers in a semiconductor material can be controlled by the applied bias, altering optical emission at the surface. In a light emitting diode, electronic injection of excess charge into a semiconductor stimulates radiation emission. Analogously, the extraction of charge carriers suppresses radiation emitted from the sample. In the infrared spectral region, radiation emitted from a semiconductor defines the apparent temperature of the material. Control of the apparent temperature of infrared material has direct application in radiation shielding for room temperature detectors, covert communications and marking targets in the infrared. Radiation shielding in a room temperature imager has the potential to increase sensitivity five to ten times expanding the application base of room temperature infrared imagers. This program will develop materials where the apparent temperature can be modulated above and below the background level, with an average level of zero. Imagers without the specific code used will not have capability to detect the modulation. Imagers cued to the code will detect the modulated signal. This program will transition to defense systems via industry.

(U) Program Plans:

FY 2008 Plans:

- Demonstrate detection of modulated signal with zero average using existing 3-5um NL material.

FY 2009 Plans:

- Reduce Long-Wave Infrared (LWIR) dark current and material doping by a factor of 10.
- Investigate growth of LWIR material on silicon substrates for larger area, lower cost and longer range.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

	FY 2007	FY 2008	FY 2009
Cost Effective Low Volume Nanofabrication	0.000	0.000	3.000

(U) The Cost Effective Low Volume Nanofabrication program will develop revolutionary circuit design methodologies combined with hybrid lithography tools to enable cost-effective low volume nanofabrication for DoD applications. Moore's law has driven the silicon industry for several decades with the minimum feature size on an integrated circuit (IC) reduced to 45 nm for today's commercial products. Due to challenging patterning requirements and complex circuit designs, costs of lithography tools and masks have become unaffordable for low-volume manufacture, i.e., military electronics or application specific integrated circuit (ASICs). Similarly, the circuit design, verification, and testing costs have also grown exponentially further preventing military electronics from using advanced silicon technology nodes. Military electronics capabilities are currently limited by the high cost of nanofabrication. To solve this important problem, DARPA has invested in a variety of maskless patterning technologies including parallel e-beam arrays, parallel scanning probe arrays, and an innovative e-beam lithography tool. This program will develop revolutionary circuit design methodologies coupled with innovative hybrid maskless patterning tools to realize cost-effective nanofabrication for low-volume defense or commercial ASICs. Such an approach can also address the nanofabrication requirements of other low-volume DoD technologies such as photonics and MEMs.

(U) Program Plans:

FY 2009 Plans:

– Evaluate the efficacy of regular geometry templates for improving lithographic performance for more robust imaging, simplified design/layout process, and increased throughput for maskless lithography methods.

	FY 2007	FY 2008	FY 2009
Technology for Ultra-High-Linearity Mixers	0.000	0.000	5.000

(U) The Technology for Ultra-High-Linearity Mixers program goal is to develop ultra-high-linearity electronic mixers to support the need of wideband high-dynamic-range receivers. To fully realize the capabilities of the ultra-high-linearity low-noise amplifiers (LNA) and ultra-high-dynamic-range analog-to-digital converters (ADCs) currently being developed under other DARPA programs, the dynamic range requirements

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

through the receiver chain will need to be larger. Since the mixer is a critical part of the receiver and is located between the LNA and ADC, this challenging dynamic-range goal will require the output third intercept point of the mixer to be larger than +60 decibel milliwatt (dBm). This regime of linearity performance is well beyond current state-of-the-art. Although the linearity of the mixer usually increases with the power of the associated local oscillator, the projected power required to meet the +60dBm requirement will be impractical for most applications. Thus, this proposed project will focus on developing the necessary technologies to enable a mixer without an additional power penalty.

(U) Program Plans:

FY 2009 Plans:

- Develop scalable ultra-high speed gallium nitride (GaN) High Electron Mobility Transistor device technology.
- Develop ultra-high linearity mixer circuit architecture.
- Demonstrate integration technology for ultra-high-linearity mixer.

	FY 2007	FY 2008	FY 2009
Disruptive Manufacturing Technologies (DMT)	3.008	3.368	5.392

(U) The goal of the Disruptive Manufacturing Technologies (DMT) program is to achieve significant and pervasive cost savings, and/or decreases in cycle time, for existing or planned procurements. There has been a long-standing desire to replace traveling wave tube amplifiers (TWTAs), which are pervasive in nearly all electronic warfare (EW), information warfare (IW), radar, and communication systems, with lower cost solid-state components. The DMT program will merge Polystrata™ and GaN technologies to eliminate the need for monolithic microwave integrated circuits (MMICs). The direct product replacement transition candidate for this program is the TWT power amplifier output stage in the AN/ALE-55, Fiber Optic Towed Decoy for the Navy's new F/A-18 E/F Super Hornet, and the Air Force B1-B and F-15 platforms. It will be replaced with solid-state hybrid microwave integrate circuit (HyMIC) modules developed by merging Polystrata™ and gallium nitride (GaN) technologies. The result will be a 10x reduction in TWTA cost, equaling >$150M for the Integrated Defensive Electronic Countermeasures (IDECM) program, a joint Navy-Air Force program. Beyond developing a replacement for TWTAs, HyMIC technology promises to increase adoption of high performance MMW systems employing mature III-V technologies as well as advance earlier adoption of those using nascent III-V technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:
FY 2007 Accomplishments:
– Demonstrated integration of GaN transistors and passive elements with Polystrata™ waveguides.
FY 2008 Plans:
– Demonstrate flip chip mounting on Polystrata™ structures.
– Complete proof-of-concept GaN 20 watts module implemented with Polystrata™ technology, along with a passive element library to enable development of the 57 W GaN building block.
FY 2009 Plans:
– Demonstrate a form-fit-function 160 W GaN amplifier ready for insertion into the IDECM decoy module.

	FY 2007	FY 2008	FY 2009
Electronic Miniaturization	2.800	0.000	0.000

(U) This program developed advanced electronic miniaturization technologies.

(U) Program Plans:
FY 2007 Accomplishments:
– Developed novel techniques for miniaturization of electronic components.

	FY 2007	FY 2008	FY 2009
Ultra-Low Power Electronics for Special Purpose Computers*	1.000	1.040	0.000

*Formerly Enabling Obiquitous Computing through Nanoscale Ultra-Low Power Electronics.

(U) This program developed advanced computing technology utilizing very low power electronic devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) Program Plans:
FY 2007 Accomplishments:
– Developed nanoscale low power electronics for defense applications.
FY 2008 Plans:
– Develop low power nanoscale electronics for special purpose computers.

	FY 2007	FY 2008	FY 2009
Computing and Nanoscale Electronic Processing	0.000	1.200	0.000

(U) The main objective of this program is to explore computing and nanoscale electronic processes.

(U) Program Plans:
FY 2008 Plans:
– Develop new applications for nanoscale electronics.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2008	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E				
COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	229.399	255.235	338.964	283.277	284.710	289.469	298.657
Command & Control Information Systems CCC-01	54.499	50.581	52.562	63.670	65.577	65.577	65.576
Information Integration Systems CCC-02	104.291	101.305	126.707	96.154	97.568	99.549	99.548
Classified CCC-CLS	70.609	103.349	159.695	123.453	121.565	124.343	133.533

(U) Mission Description:

(U) The Command, Control and Communications Systems program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The goals of the Command and Control Information Systems project are to develop and test innovative, secure architectures and tools to enhance information processing, dissemination and presentation capabilities for the commander. This will give the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making and execution support capability and provide secure multimedia information interfaces and assured software to "on the move" users. Integration of collection management, planning and battlefield awareness programs is an essential element for achieving battlefield dominance through assured information systems.

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. The principal element of this project is assured communications using standard and non-traditional means.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Command, Control and Communications Systems; PE 0603760E

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	227.626	256.868	267.786
Current Budget	229.399	255.235	338.964
Total Adjustments	1.773	-1.633	71.178
Congressional program reductions	0.000	-1.633	
Congressional increases	0.000		
Reprogrammings	7.600		
SBIR/STTR Transfer	-5.827		

(U) Change Summary Explanation:

FY 2007	Decrease reflects a below threshold reprogramming and the SBIR/STTR transfer.
FY 2008	Decrease reflects reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.
FY 2009	Increase reflects enhancements in the C2 area for the introduction of cognitive computing tools into on-going C2 programs, offset by other C2 program completions, increases to communications efforts to fund continuation and expansion of the Wireless Network After Next (WNAN) and Optical RF Communications programs, and increases to classified programs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Command & Control Information Systems CCC-01	54.499	50.581	52.562	63.670	65.577	65.577	65.576

(U) Mission Description:

(U) Military operations since the end of the Cold War illustrate that current theater-level command, control, communications, and intelligence/information systems lack the ability to fully support operations in complex, time-critical environments. Warfighters must be prepared for operations ranging from conflict and peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real-time, secure, situational awareness or the ability to orchestrate high-tempo planning, rehearsal, and execution. The programs in this project are developing and testing innovative, secure architectures and tools to enhance information processing, dissemination, and presentation capabilities. The programs provide the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making, and execution support capability, as well as secure multimedia information interfaces and software assurance to the warfighter "on the move". Integration of collection management, planning, and battlefield awareness are essential elements for achieving battlefield dominance through assured information systems.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR)	9.178	8.531	7.761

(U) The Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR) program improves battle management for complex air campaigns that employ new air platforms featuring precision sensors, weapons and communications relays. The JAGUAR system is driven by: 1) targeting information, both for sensor targets and strikes, expressed as point and area targets (i.e., search, combat air patrol); 2) rules of engagement and procedural constraints, such as airspace restrictions; and 3) availability of platforms, weapons, sensors, and communications equipment. From this information, JAGUAR produces ingress routes, flight schedules and patrol zones, while assuring airspace and electronic deconfliction. The technology provides pilots and commanders the option to choose conventional tactics or conceive unconventional operations. In the latter case, the system captures the innovation and retains the strategic maneuver for future mission plans. JAGUAR monitors actual plan

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

execution against expected results and alerts commanders to significant differences. The technology captures statistical descriptions of small differences to help assess the robustness of future plans. There is a Memorandum of Understanding in place with the U.S. Air Force and technology transition is planned to occur in late FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Equipped a training facility with software tools and human observers to capture plans as constructed, executed, and modified.
- Developed dynamic plan generation to accommodate popup targets or mission changes.
- Developed continuous plan monitoring to assess deviations from plans.

FY 2008 Plans:

- Develop a large-scale integration algorithm to assemble plan fragments into a synchronized operational plan.
- Build optimization tools to tailor routes, schedule events, and deconflict airspace and radio frequencies.

FY 2009 Plans:

- Conduct operationally realistic experiments at Air Force Distributed Mission Operations Center.

	FY 2007	FY 2008	FY 2009
Heterogenous Urban Reconnaissance Team (HURT)	22.270	5.000	4.358

(U) The Heterogeneous Urban Reconnaissance Team (HURT) initiative develops integrated tactical planning and sensor management systems for heterogeneous collections of unmanned platforms operating in urban environments. HURT employs a model-based control architecture with dynamic teaming and platform-independent command and control. The system registers new platforms with the battle manager (kinematics, maneuverability, endurance, payloads, and communications links) to facilitate platform-independent tasking. HURT provides a commander's interface that allows collaborative tasking of the platforms in the form of operational missions, such as search, track, identify, or engage, rather than routes and events. Additionally, it supplies computationally intensive decision aids, such as advanced 4-D airspace and groundspace deconfliction tools, route planners, and task/platform assignments algorithms. The technology presents mission status and future courses of action to commanders for collaborative adjudication. HURT enables augmentation of low-footprint, rapidly deployable, easily sustainable human command structures with teams of machines operating together. There is a Memorandum of Agreement in place with the U.S. Special Operations Command.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

(U) Program Plans:
FY 2007 Accomplishments:
– Conducted two live-fly exercises of prototype system.
FY 2008 Plans:
– Expand capability to include taskable sensors on manned aircraft.
– Integrate into combat aviation brigade testbed at Ft. Hood.
FY 2009 Plans:
– Support user training operations at Ft. Hood.

	FY 2007	FY 2008	FY 2009
Collision Avoidance & Dynamic Airspace Control*	2.500	4.000	5.000

*Formerly Dynamic Airspace Allocation.

(U) The goal of the Collision Avoidance and Dynamic Airspace Control program is to maximize airspace utilization through dynamic military airspace management. Today's labor-intensive human centric airspace management processes result in an inefficient use of airspace and limit the density and responsiveness of airborne systems. Further, the introduction of unmanned aircraft has increasingly complicated the challenge, leading to operating constraints and the potential for mishaps related to the different characteristics of manned and unmanned systems. This program will evaluate and develop technologies for an automated and distributed system that efficiently manages all objects in the airspace to include munitions, manned and unmanned aircraft. Specifically focused on the needs of the military, the program will enable provable levels of safety while ensuring military freedom of maneuver. The automated system will be developed as a replacement for current management systems and processes and will support all service users. Challenges to be addressed include complex algorithms and network information exchange, and integration with legacy, degraded and intentionally disruptive aircraft. The program will also explore novel concepts of operation enabled by radically enhanced airspace utilization. The capabilities developed by this program will benefit all of the Services.

(U) Program Plans:
FY 2007 Accomplishments:
– Examined potential system architectures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

FY 2008 Plans:
- Develop and simulate potential system architecture models.
- Develop a preliminary design for the system.

FY 2009 Plans:
- Demonstrate critical technologies.

	FY 2007	FY 2008	FY 2009
Advanced Ground Tactical Battle Manager	4.133	6.000	8.389

(U) The Advanced Ground Tactical Battle Manager program develops automated decision support tools for Army and Marine tactical commanders at the division level and below. The program also provides support for combined operations employing dismounted soldiers, manned platforms, and autonomous vehicles. The tool elicits skeletal courses of action through a graphical interface with unit commanders and extends plans by applying adversarial reasoning techniques to identify vulnerabilities and opportunities in the predicted enemy course of action. Finally, it examines modifications or counteractions to reduce vulnerabilities. Products will transition to the Army.

(U) The Real-time Adversarial Reasoning and Decision-making (RAID) program develops technologies to anticipate enemy actions, especially in urban operations against irregular combatants. Experiments demonstrate how RAID can assist a Distributed Common Ground System-Army operator in the preparation of better intelligence products as compared to those built by un-assisted analysts.

(U) The Know What Is to Know Subsystem (KWIKS) develops a support tool that autonomously and continually, during the execution of a military operation, tracks the state of what is known about the environment (and how well), and what are the forms and priorities of additional collection needs. This tool will provide substantially automated assistance to the current (laborious and non-real-time) process of collections planning, which currently includes manual steps such as analysis of external context, enemy and neutral goals and capabilities, and assessment of known threats. The overall benefit is more effective, rapid, complete identification of enemy state, resulting in achieving mission objectives with fewer friendly casualties and lower collateral damage.

(U) The Deep Green subsystem combines anticipatory planning with adaptive execution, providing military decision makers with capabilities on the battlefield that the IBM computer ‘Deep Blue’ brings to the chessboard. This effort explores closed-loop simulation to integrate planning,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

execution, and will incorporate continuous learning. The technology will also employ software agents to monitor the execution of the current operation against the plan, identify variations as the scenario unfolds and consistently explore the possible future states of the battlefield. This technology allows a proactive rather than reactive stance in the command of the battlefield giving the U.S. warfighter the advantage.

(U) Program Plans:

– RAID

FY 2007 Accomplishments:

-- Developed an exercise environment with the Army Battle Command Battle Labs.
-- Defined interfaces to existing and future Army intelligence and command and control systems.
-- Completed experimentation on predictions and counteractions.
-- Completed experiment on concealment and deception.

FY 2008 Plans:

-- Integration and transition into the Distributed Common Ground System-Army.

– KWIKS

FY 2008 Plans:

-- Extend and develop emerging computational techniques for analysis of information state under conditions of adversarial concealment and deception and partial observability.
-- Design and execute a series of realistic wargame-based experiments to enhance and validate the capabilities of the system.

FY 2009 Plans:

-- Adapt and validate the system for transition requirements.

– Deep Green

FY 2008 Plans:

-- Create initial Deep Green subsystems/components including Crystal Ball (assembles a diverse set of candidate plans and provides an integrated probabilistic overlay for all), Commander's Associate (induces the commander's intended plan from multi-modal man-machine dialog), and Blitzkrieg (fast multi-resolution combat model that permits high quality playoffs across the portfolio of planning options).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

FY 2009 Plans:

-- Extend technologies to monitor an ongoing operation and update the likelihoods that the possible futures being generated by Deep Green will actually occur.

-- Integrate major components to produce an initial prototype Deep Green system that enables proactive (vice reactive) battle management.

	FY 2007	FY 2008	FY 2009
Urban Commander	4.006	8.000	6.000

(U) The Urban Commander thrust develops automated tools to help ground commanders construct detailed, realistic operational plans, particularly in nontraditional and urban environments. Partial plans are represented in hierarchical task networks and visualized through synchronization matrices, icon overlays, or tactical sketch animations. Commanders and staff modify, refine, and extend a plan through voice, sketching, and semi-structured input. The system links fragments constructed at different sites, transfers information among related parts, and discovers and recommends solutions for inconsistencies. The system continuously compiles a set of plan cases and employs analogical matching to propose extensions to current plans suggested by past experience. Plan elements are communicated through an integrated set of protocols from the unit commander down to dismount commanders equipped with advanced heads-up displays and helmet-worn sensors. Finally, the program continuously assesses progress against the operational plan and alerts users to significant deviations.

(U) The Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS) program develops, integrates, and demonstrates a soldier-worn visualization system. Both helmet-mounted and handheld versions are being built. The system consists of five elements: 1) multi-spectral sensor suite; 2) high resolution digital display; 3) inertial measurement unit; 4) high-speed processor; and 5) power supply. MANTIS provides the warfighter with digitally-fused imagery in real time from the multi-spectral sensor suite, exploiting three distinct spectral bands. The fused imagery is shown on two displays; one has a wide field-of view and the other a narrow field-of-view. When viewed together, the system furnishes a larger field-of-view image with simultaneous high resolution and stereo capability. The system also allows the warfighters to record and "play back" the video while on the battlefield. MANTIS interfaces with the future soldier's advanced communications and networking systems, allowing the warfighter to send/receive video images and position information with fellow soldiers and commanders in real time. There is a Memorandum of Agreement in place with the Program Executive Officer Soldier, and Night Vision & Electronics Sensor Directorate for transition at the conclusion of Phase III anticipated to be completed early in FY 2008.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

(U) The ULTRA-VIS program develops an integrated system to provide Army and Marine small unit leaders with the ability to conduct daytime operations in an urban environment. The system includes a conformal, see-through, optical waveguide visor that displays intra-squad commands, alerts, and even icons that are attached to the urban landscape. Network protocols support information management to allow the squad leader to hand-off actionable information and direct alerts to the squad/fire teams for real-time collaboration without overload. ULTRA-VIS relays standard phrases and visual annotations that can be issued covertly, avoiding hand signals or shouting that may be recognized by the enemy. A robust, optically-assisted navigation technique will provide continuous geo-location and head tracking for each squad member while operating in GPS-denied environments. The system synthesizes weapon fire observables across a networked moving squad to detect and locate hostile weapon fire using a helmet mounted IR sensor and small acoustic array for precise sniper location and real time designation within the warfighter's visor. ULTRA-VIS empowers the small unit leader with a clear tactical advantage through inter/intra-squad collaboration, heightened awareness and the ability to take decisive action while on-the-move. The ULTRA-VIS technology is planned for transition to the Army.

(U) Program Plans:

– Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS).

FY 2007 Accomplishments:

-- Fabricated three MANTIS functional prototypes (two helmet-mounted, one handheld) for evaluation.
-- Conducted independent laboratory/field tests of MANTIS prototypes.

FY 2008 Plans:

-- Transition to the U.S. Army (PEO Soldier).

– ULTRA-VIS

FY 2008 Plans:

-- Develop see-thru display conformal visor using holographic waveguide.
-- Develop optically-assisted navigation for continuous geo-location and pose estimation.
-- Develop interface to actuate non-verbal commands and post icons onto a shared urban landscape.

FY 2009 Plans:

-- Create network protocols for alerts and information management for inter-squad collaboration.
-- Develop fusion algorithms to precisely locate weapon fire using IR and acoustic signatures within a moving networked squad.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

	FY 2007	FY 2008	FY 2009
Tactical Group Decision Analysis Support System	2.329	2.000	0.000

(U) The Tactical Group Decision Analysis Support Systems program develops distributed group decision analysis and network management tools. These tools increase the tempo of the tactical commander's observe-orient-decide-act loop, the quality of decisions, the contribution of data point input across the organization, and the necessary communications capabilities needed to support this decision structure. This effort develops a set of tools to evaluate risks and identifies optimal "network configuration pivot points," and automates specific configurations for each network element. The Command, Control, Communications, and Computers (C4) tool suite provides the warfighter with a reliable communications network, which is critical to successful military operations. The tools apply to crisis management situations for tactical commanders and could be transitioned to existing emergency response command and control systems as well as emerging tactical command and control systems. The technologies developed under this program transition to the Army.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed automated reasoning including fast Boolean (a deductive logical system) solvers that satisfy million-variable problems in seconds.
- Built "model finders" that compile first-order logic into Boolean logic and take advantage of Boolean solvers.
- Developed strategies to formalize planning problems as deductive reasoning problems.

FY 2008 Plans:

- Perform scaling and laboratory-based experimentation.

	FY 2007	FY 2008	FY 2009
Increased Command and Control Effectiveness (ICE)	0.000	3.000	6.000

(U) The Increased Command and Control Effectiveness (ICE) program develops and incorporates cognitive systems technology into operational Command, Control, and Intelligence (C2I) systems within each service. DARPA's Cognitive Systems programs have been developing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

the machine learning, reasoning, and human-machine dialogue technologies necessary to create cognitive assistants. This new technology promises to enable information systems to adapt – during deployment, in real time – to the changing conditions that military commanders confront. Information systems automatically adjust to new environments and new users, helping commanders adapt to evolving situations and priorities, and accelerating the incorporation of new personnel into command operations. This program funds portions of the technologies developed in the Personalized Assistant that Learns (PAL) program (funded in PE 0602304E, Project COG-02) that are ready for application to command and control systems.

(U) From an operational perspective, cognitive approaches to information processing offer three major enhancements to current command and control systems. First, they efficiently sort, segregate, separate and identify relevant data based on priority hierarchies established by the command structure. For example, image data can be selected based on target priority, historical context or anomalous changes. Second, cognitive technologies adapt the presentation of information to suit the needs and preferences of the individual commander. Finally, cognitive systems make relevant data generally available to all users both during collaborative planning processes and individual tactical analysis. In short, cognitive technology is introducing the equivalent of "just in time" inventory management to information management for command decision-making.

(U) The Army's Command Post of the Future (CPOF), STRATCOM's Strategic Knowledge Integration Web (SKIweb), the Navy Marine Corp Intranet (NMCI), and the Web Timeline Analysis System (WebTAS) are candidate systems for insertion of this new technology. This will ultimately reduce the staffing footprint of command centers.

(U) Program Plans:

FY 2008 Plans:

- Develop initial prototypes of cognitively-enhanced versions of the following systems suitable (e.g., certifiable) for use on military networks: Command Post of the Future (CPOF); Strategic Knowledge Integration Web (SKIweb); Navy Marine Corp Intranet (NMCI); and Web Timeline Analysis System (WebTAS).

FY 2009 Plans:

- Develop and refine advanced operational prototypes of cognitively-enhanced versions of the CPOF, SKIweb, NMCI, and WebTAS systems that would provide users with advanced information management capabilities such as learning to anticipate users' information needs, pre-fetching needed information, learning users' interests, alerting users about the occurrence of events of interest, coordinating teams, and managing message traffic.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

– Demonstrate, test, and evaluate PAL-enhanced information systems in military exercises to validate that the PAL technologies are robust to the dynamics and uncertainties of the battlefield and dramatically compensate for end-user "cognitive overload".

	FY 2007	FY 2008	FY 2009
Predictive Battlespace Awareness	2.258	3.000	1.000

(U) The Predictive Battlespace Awareness program develops tools to interactively draw upon a distributed network of human experts, allowing them to collaboratively anticipate an opponent's future actions. The program enables commanders to pre-position sensors, weapons, and information to counter the opponent's actions. The program develops model and knowledge-based techniques to predict areas of operation and tactical objectives. The technology supports the modeling of courses of action ranging over time horizons from hours to days. Program techniques permit "on-the-fly" tailoring of models and contextual knowledge, and leverage knowledge of sensor effectiveness, mobility factors, tactical templates, and target characteristics. Techniques include variable-fidelity prediction, such as the ability to determine both target locations over minutes and force zones of influence over hours. The tools anticipate enemy operations in time to thwart them with effects-based targeting, enabling use of sensors and other resources in proactive modes. The program both enables commanders to avoid canned responses and supports rapid incorporation of insights about new enemy strategies, capabilities, and tactics from peacetime to the heat of battle. The program significantly enhances today's mostly manual, slow planning, and analysis processes. Technologies are planned to be transitioned to the Air Force Distributed Common Ground Station.

(U) Program Plans:

FY 2007 Accomplishments:

– Developed algorithms to decompose information needs into steps to be performed by experts.
– Developed schema to allow experts to register with the system.

FY 2008 Plans:

– Downselect algorithms for match-making, negotiation, monitoring and assimilation.

FY 2009 Plans:

– Define a system architecture.
– Integrate selected technologies and conduct collaboration demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

	FY 2007	FY 2008	FY 2009
Predictive Analysis for Naval Deployment Activities (PANDA)	7.825	11.050	14.054

(U) Predictive Analysis for Naval Deployment Activities (PANDA) develops technology to automatically learn normal activity models (motion and emission) for maritime surface vessels, automatically detect anomalous behavior, provide context modeling to resolve known categories of anomalies (e.g., due to weather and business rule changes), and alert processing. The resulting technology can be extended and applied to a wide range of applications including ground vehicles, troop movements, and individual targets of interest (e.g., suspected insurgents), as the methods of tracking those targets improves. The initial application will be anomaly detection in the maritime domain. PANDA technologies are planned to transition to the Office of Naval Intelligence and the Fleet Commanders.

(U) Program Plans:

FY 2007 Accomplishments:

- Implemented initial motion-based learning algorithms.
- Implemented and tested adaptive context model.

FY 2008 Plans:

- Demonstrate that individual and class-of-vessel motion-based activity patterns can be learned and used to detect anomalies.
- Use patterns to predict movements and classify (groups of) vessels as potentially (non) hostile with a low incidence of false alarms.
- Discover and learn correlated activities, integrate on two nodes simultaneously, and conduct SeaTrial Demonstration.

FY 2009 Plans:

- Rapidly relearn models in response to sudden changes and generate timely alerts, integrate with three nodes simultaneously, and conduct SeaTrial Demonstration.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2008	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02				
COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Information Integration Systems CCC-02	104.291	101.305	126.707	96.154	97.568	99.549	99.548

(U) Mission Description:

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. Through the use of wideband dissemination and integrated sensor management, the project will also facilitate multi-site, real-time, collaborative situation assessment and course-of-action evaluations to enable true network centric warfare concepts. This project hosts many of DARPA's most innovative communications and networking systems.

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

	FY 2007	FY 2008	FY 2009
Polarized Rotation Modulation (PZRM) Communications	4.127	1.398	1.000

(U) The goal of the Polarized Rotation Modulation (PZRM) Communications program is to develop new extremely high data rate, point-to-point, or point-to-multipoint wireless communications waveform using the PZRM/Orthogonal Signal Spectrum Overlay (OSSO) communications concept to exploit the presently unused polarization and rotation dimensions of radiation. The PZRM communications program will investigate the use of polarization, including OSSO, modulation and the ability for conventional radios to carry all information over the transmitted signal amplitude, phase and frequency. Polarization modulation introduces an additional dimension. A radio with four polarization possibilities would transmit four times the information with all other aspects of the waveform held constant. OSSO enables multiple orthogonal signals to overlay one another in the same radio bandwidth thereby increasing spectral efficiency. Use of the antenna as part of the information processing architecture of a radio has not been previously performed. This technology will greatly increase the capacity of existing radio channels without increasing spectrum or modem complexity. The program will be demonstrated as an enhancement to an otherwise state-of-the-art communications system. The PZRM technology will transition to Service applications in FY 2009.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) Program Plans:

FY 2007 Accomplishments:

- Performed simulations to determine bit error rates and the optimum modulation schemes commensurate with the center frequencies and bandwidth permissible.
- Conducted simulations to verify performance predictions and identify component elements.

FY 2008 Plans:

- Conduct over-the-air satellite testing to demonstrate utility over waveforms currently in use.

FY 2009 Plans:

- Complete final demonstrations and transition to the Services.

	FY 2007	FY 2008	FY 2009
Advanced HF Communications	3.300	2.500	0.000

(U) The goal of the Advanced HF Communications program is to investigate techniques to provide always-available, high-rate communications at long ranges for Special Operations Force (SOF) teams using miniaturized equipment. Currently SOF teams rely on satellite communications (Satcom) for long-range connectivity. However, Satcom requires line of site access, and channel availability. The Advanced HF Communications will develop antenna and radio technology to provide high-rate communications at long ranges using ground wave and near vertical incidence skywave (NVIS) propagation. A fundamental challenge is in reducing the size, weight and power (SWaP) requirements for SOF applicability. The technologies developed under this program are planned for transition to the Special Forces.

(U) Program Plans:

FY 2007 Accomplishments:

- Designed miniaturized antennas that allow man-portable radio systems to operate over a wideband at HF and low VHF frequencies to permit substantially enhanced range and data rate with maximum penetration in jungle environments.
- Conducted field tests in a dense pine forest.
- Demonstrated an over-the-horizon point-to-point communication capability that supports real-time video with low-output power over tactically significant ranges (> 1 km).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2008 Plans:

– Perform propagation experiments to determine atmospheric effects on communications using the ground wave electromagnetic propagation modality.

	FY 2007	FY 2008	FY 2009
Next Generation (XG)	3.994	1.600	1.000

(U) The Next Generation (XG) program goals are to develop both the enabling technologies and system concepts to provide dramatic improvements in assured military communications in support of a full range of worldwide deployments through dynamic spectrum access. U.S. Forces face unique spectrum access issues in each country in which they operate due to competing civilian or government users of national spectrum. These constraints must be reflected in all force planning and may preclude operation of critical systems. Coalition and allied operations are even more complex to manage, and may severely limit the U.S. ability to fully exploit its superiority and investment in information technology. The XG program approach is to develop the theoretical underpinnings for dynamic access to the spectrum, the technologies and subsystems that enable dynamic access, and the system prototypes to demonstrate applicability to legacy and future DoD radio frequency emitters. The program is investigating methods to leverage the technology base in microelectronics with new waveform and medium access and control protocol technologies to construct an integrated system. The program goals are to develop, integrate, and evaluate the technology to enable equipment to automatically select spectrum and operating modes to both minimize disruption of existing users, and to ensure operation of U.S. systems. The result of the XG program will be to develop and demonstrate a set of standard dynamic spectrum adaptation technologies for legacy and future emitter systems for joint service utility. The XG communications technology is planned to transition to the Army for implementation in a range of current and future communication systems including the Joint Tactical Radio Systems clusters.

(U) Program Plans:

FY 2007 Accomplishments:

– Developed initial set of hardware prototypes and undertook initial field experimentation.
– Developed and evaluated approaches for implementation complexity, on-board processor and memory capability/power, overhead, scalability and performance.
– Developed final set of hardware prototypes to evaluate and demonstrate system capabilities in an operational exercise.
– Demonstrated spectrum agility performance of prototypes in field experiments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– Demonstrated spectrum effectiveness and operational characteristics.
– Initiated transition to several candidate military radios.

FY 2008 Plans:

– Develop and demonstrate large-scale network organization and adaptation.
– Conduct medium and large-scale military scenario demonstrations.

FY 2009 Plans:

– Continue transition to candidate military radios.

	FY 2007	FY 2008	FY 2009
Advanced Speech Encoding (ASE)	5.383	3.992	3.995

(U) The Advanced Speech Encoding (ASE) program will achieve an order of magnitude reduction of voice communication bit rates in noisy military environments over current state-of-the-art voice encoders (VOCODER). Such a reduction will significantly decrease the probability of detection of transmitted signals and will also decrease the required transmit energy, thereby increasing battery lifetime. The program will pursue two novel approaches toward achieving its goal. One approach builds upon multiple noise-immune sensors that have been combined with traditional coding algorithms to achieve significant improvements in intelligibility and quality in harsh noisy environments at 2,400 bits per second (bps). This approach will be extended to nontraditional ultra-low-bit-rate coding algorithms in order to achieve 300 bps coding capability in harsh military environments. Alternative approaches will also be explored, such as the communication without acoustic information achieved by extracting laryngeal and sublingual muscle signals that are produced when a person generates sub vocal speech. This approach will yield a revolutionary capability in situations where stealth is of the utmost importance, or in situations where acoustic signals cannot be used, such as under water. The ASE technology is planned for transition to the Special Operations Command and the Communications and Electronics Command of the U.S. Army after a prototype demonstration scheduled for FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

– Demonstrated that a 600 bps coder substantially exceeded the ASE program goal in three harsh noise environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2008 Plans:
- Develop a prototype real-time ultra-low-bit-rate communication system integrating the ASE VOCODER technology and a military radio.
- Develop techniques to capture and enhance sub-vocal signals to enable stealth communication among warfighter teams.
- Explore the nature of sub-vocalic signals (physiological source, speaker dependence, and robustness) and the information content of the signals.

FY 2009 Plans:
- Demonstrate a robust sub-vocalic silent-speech communications system.
- Demonstrate the ultra-low-bit-rate communication system in the field.

	FY 2007	FY 2008	FY 2009
Optical & RF Combined Link Experiment (ORCLE)	16.180	34.142	52.067

(U) The Optical & RF Combined Link Experiment (ORCLE) program seeks to develop combined radio frequency (RF) and free space optical (FSO) communications as well as networking technologies that exploit the benefits of complementary path diversity. This effort using optical and RF communication adjunct techniques will demonstrate improved battlespace communications using a hybrid RF and FSO link in air-to-air-to-ground environments. The central challenge is to enable optical communications bandwidth without giving up RF reliability and "all-weather" performance. ORCLE will develop RF and FSO propagation channel analysis, coding techniques and modeling to include weather, atmospherics and aero-optics to provide the joint force commander assured high-data rate communications. The technical objective is to prototype and flight demonstrate hybrid FSO/RF air-to-air-to-ground links that combine the best attributes of both technologies and simulate hybrid network performance. The ORCLE technology is planned for transition to the Special Operations Forces and the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:
- Completed initial investigation and research of optical pointing, acquisition and tracking.
- Demonstrated ability to transfer large data rates using combined optical and RF links over long distances.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2008 Plans:
- Plan range and flight demonstrations of air-to-ground-to-ground hybrid FSO/RF links with high availability and gigabit data flows.
- Design and engineer a prototype hybrid FSO/RF high-capacity network system.
- Investigate the optical channel obscuration mitigation using ultra-short pulse lasers and partially coherent beams.
- Construct and field test a brassboard system incorporating the FSO/RF components and dynamic network communication and interface system.
- Plan experiments of air-to-air-to-ground nodes that will operate in direct interface to the Global Information Grid (GIG) and the tactical network gateway.

FY 2009 Plans:
- Perform range and flight demonstrations of air-to-ground-to-ground hybrid FSO/RF links in operational representative environment.
- Demonstrate high availability and gigabit data flow network performance with air-ground-ground using multiple FSO/RF nodes.
- Integrate and test the ORCLE terminals to verify performance and readiness for field experiments and demonstrations.
- Develop, design, and build hardware and software of a prototype system for integration into military air and ground platforms.
- Plan field demonstrations of ORCLE networking that supports multiple airborne platforms, a ground node with direct interface to the GIG, and a ground node with an interface to a tactical gateway supporting IP-addressable nodes.

	FY 2007	FY 2008	FY 2009
Disruption Tolerant Networking (DTN)	8.425	7.205	7.625

(U) The Disruption Tolerant Networking (DTN) program is developing network protocols and interfaces to existing delivery mechanisms ("convergence layers") that provide high reliability information delivery using communications media that are not available at all times, such as low earth satellites, UAV over-flights, orbital mechanics, etc. The program is developing a single model for bundling information and ensuring its delivery, through a series of episodic communications links, from generator to user. Mechanisms and protocols that reduce bandwidth consumption, reduce latency, and improve reliability of information delivered to tactical deployments will be explored. The program is also exploring a new security model which protects information held in portable devices. To maximize the applicability and commercial viability of these protocols, and develop the basic software in an open source mode, the military, commercial and Internet communities have been engaged.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

These protocols will be implemented in a typical military system to verify both the performance of the protocol and to validate the utility. The DTN technology is planned for transition to the Army and Marines in FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Commenced research to show "fuzzy scheduling" can make network routing decisions in the presence of uncertainty about available or optimal paths.
- Developed mechanisms to allow code-base-independent environmentally-aware selection of routing algorithms.
- Demonstrated that information organized into bundles can be delivered across intermittently-connected networks.
- Enabled networks to deliver traffic without the end-to-end address and routing information using deferred, hierarchical address binding techniques.
- Demonstrated trusted delivery of bundles across networks in which access to a public key infrastructure is not reliable.
- Demonstrated distributed in-network cache and indexing services and improved reliability with DTN-over-Internet Protocol (IP) vice end-to-end IP.
- Demonstrated information binding on demand from a network cache.
- Investigated policy cognitive operation by moving intelligence into networks to make the best choices on delivery.
- Completed initial integration of DTN into USMC Command and Control On-the-Move Network Digital Over-the-Horizon Relay (CONDOR) system; incorporated DTN into USMC laptop build.

FY 2008 Plans:

- Integrate distributed in-network caching and indexing services into DTN system.
- Integrate information binding on demand from a network cache into DTN system.
- Demonstrate temporal security architecture.
- Demonstrate policy cognitive operation choosing best delivery options.
- Complete equipment integration into USMC CONDOR systems. Integrate DTN into military tactics, techniques, and procedures.

FY 2009 Plans:

- Integrate temporal security architecture into DTN.
- Deploy prototype DTN system tactical networks.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX)*	11.926	3.229	1.000

*Formerly Network Centric Operations/Battle Command.

(U) The DoD is transforming to a more network centric focus for military operations. Network centricity, among other benefits, facilitates the sharing of situation information and access to resources. Shared situation awareness enables collaboration and self-synchronization at all operational levels thereby greatly increasing mission effectiveness. Military campaigns in the future will not necessarily be focused solely on major military operations. These campaigns will involve attempts at conflict avoidance, and if this fails, possibly major combat operations with periods of various security, stability, reconstruction, transformation and transition operations. Future campaigns will be characterized by an increased demand for the commander to employ the most appropriate actions (diplomatic, information operations, military, economic, etc.) against the adversary's various political, military (air, land and sea; regular or irregular), economic, social, information distribution, infrastructure, etc. systems. Commanders in the future will use network centricity to access a larger base of knowledge sources and a greater range of resources and actions. Concurrently, the commander will be challenged to exploit these capabilities to achieve a mixture of appropriate effects.

(U) The Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX) research effort is developing technologies that will enhance the capability of leaders to plan and conduct government campaigns. This includes a comprehensive suite of decision support tools that help leaders with: visualizing and understanding the situation and the complex operational environment they must operate in; constructing and managing plans that enable the commander to synchronize and integrate interdependent effects over a long period of time; employing the best sequence of unified actions to produce the desired effects; and generating and exploring options and courses of action to understand the range of outcomes and appreciate the side effects that may occur.

(U) Technologies developed in the program are planned to transition to the Army Network Enabled Battle Command program and to the U.S. Joint Forces Command with more comprehensive capabilities transitioning incrementally by FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Successfully conducted limited objective experiments with Joint Force Command (JFCOM) and other military participants.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– Developed and demonstrated technologies for integrating modeling and visualization techniques into action/effects exploration and campaign planning with an emphasis on modeling an adversarial coalition's various political, social, economic, information dissemination, service infrastructure, etc. systems as well as its military or insurgent capabilities.

FY 2008 Plans:

– Develop and demonstrate technologies to support humans in authoring courses of action, development and campaign plans; decompose objectives, to effects, to nodes, to actions; capture and model interdependencies between assumptions, activities and intended objectives, and between intended and unintended effects; and assist the human in synchronizing objectives and activities.

FY 2009 Plans:

– Complete final demonstration and transition to the Services.

	FY 2007	FY 2008	FY 2009
Retro-directive Ultra-Fast Acquisition Sensor (RUFAS)*	5.345	3.530	0.000

*Formerly Ultra-Fast Radar.

(U) The Retro-directive Ultra-Fast Acquisition Sensor (RUFAS) effort will design, construct, and demonstrate an X-band noise correlating radar with a retro-directive antenna. This effort will research and develop a new type of radar sensor based on the correlations of the Gaussian noise received by an antenna array from a small object located in the far field of the antennas and the retro-directive re-radiation of the correlated noise. Combining and tailoring noise correlating interferometry and retro-directive antenna arrays into retro-directive noise-correlating (RNC) radar will allow the radar to operate in omni-directional search mode. The result of this project will be a new type of search-mode radar having promising performance in terms of short acquisition time and low probability-of-intercept. The RUFAS technology is planned for transition to the Army and Marines.

(U) Program Plans:

FY 2007 Accomplishments:

– Modeled, simulated, and demonstrated detection of fluctuating and multiple targets.
– Conducted X-band radar free space test using early prototype bench equipment.
– Developed prototype X-band noise correlating radar with a retro-directive antenna with five times reduction in acquisition time compared to traditional electronically-steered search-mode radar and mechanically scanned radars.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– Conducted successful field demonstration of scale projectile target.

FY 2008 Plans:

– Design and demonstrate ultra-fast radar using retro-directive antenna arrays that will show a significant reduction in probability-of-intercept compared to traditional search radars based on coherent transmitters.
– Conduct production manufacturability study.
– Conduct cost benefit track study to verify RUFAS design capabilities.
– Develop full-scale prototype radar with the size, weight, and power required for military utility.

	FY 2007	FY 2008	FY 2009
Fiber-Optical Network for Aerospace Platforms	3.525	2.500	5.845

(U) The Fiber-Optical Network for Aerospace Platforms program will facilitate building or upgrading military aircraft and other aerospace platforms with a fiber-optical networking infrastructure. This will have many capabilities that are well beyond those of currently used copper-based technology. Originally, the program focused on specific technologies for application on the Navy's EA-6B Prowler aircraft, however, the program has been broadened to focus on technologies that will provide advanced capabilities to a multitude of military aircraft, shipboard and aerospace platforms. These new capabilities include: scalability in bandwidth and number of connected devices; immunity to electromagnetic interference (EMI) and cable cross-talk; reduced cable and overall system weight and volume; increased reliability without an associated weight or volume penalty; ease of integration and future upgradeability; and the ability to carry mixed analog and digital signal formats. This will be accomplished by taking full advantage of fiber-optical wavelength-division-multiplexing (WDM) technology and leveraging optoelectronic and photonic integration techniques developed in DARPA photonics components program. To reduce size, weight and power requirements and to increase the reliability and the flexibility of interconnecting arbitrarily placed client devices with various signal formats, use will be made of passive, transparent, wavelength-routing technology at the core of the network, and tunable optical transmitters and receivers (transceivers) to inter-connect the client devices at the edge of the network. The technologies developed under this program are planned for transition to the Services in FY 2010.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) Program Plans:

FY 2007 Accomplishments:

- Developed unclassified networking requirements for various tactical and wide body military aircraft for enabling open discussions in the international standards bodies.

FY 2008 Plans:

- Develop the architecture of the avionics optical network that satisfies the aforementioned requirements.
- Develop the following key optoelectronic components: tunable digital and analog transmitters, multi-channel digital and analog receivers, tunable digital and analog receivers, and passive wavelength routing components.
- Demonstrate the ability to integrate into a single component the appropriate combination of optoelectronic devices to reduce system size, weight and power.

FY 2009 Plans:

- Validate the architecture of the fiber-optic avionics network and conduct an analysis to estimate the resulting network reliability and survivability under various failure scenarios.
- Continue development of the key optoelectronic components.
- Test the ability to interconnect digital and analog client equipment with the developed optoelectronic components.

	FY 2007	FY 2008	FY 2009
Next Generation Routing and Addressing	3.557	3.750	4.550

(U) The Next Generation Routing and Addressing program seeks to develop networks that use topographically distributed addresses (e.g., geographically or by organizational unit). Current network routing methodologies use internet protocol (IP) address numbers that are distributed in no defined pattern or methodology. As a result, current routing systems spend large amounts of time and computing power updating and maintaining tables that "point" to where different IP addresses are located geographically. The development of new network addressing schemes will reduce the load on routers as well as greatly simplify router configuration. These networks will be a paradigm shift such that numbered IP addresses will no longer exist, and changes to the Domain Naming Server (DNS) system will allow for services to mobile users. This program is planned for transition to the Services in FY 2012.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted market survey of existing router techniques and current research efforts.
- Conducted research on Routing Protocols and Management (RPM) for high capacity networks.
- Developed concept ideas for novel methods to allow multi-path route discovery, improved network routing efficiency, and improved authentication/attribution.

FY 2008 Plans:

- Develop machine naming schema for data packets that are geographically based and that allow for fine grained control of precedence and improved quality of service capabilities.
- Develop tactical router replacements that work with existing computers/routers and require no new configuration and enable self-forming networks that will result in at least an order-of-magnitude reduction in training, configuration, and installation time.

FY 2009 Plans:

- Develop changes to DNS functions to accommodate the forwarding services to mobile users.
- Conduct demonstrations in operationally relevant environments.

	FY 2007	FY 2008	FY 2009
Scalable MMW Architectures for Reconfigurable Transceivers (SMART)	7.534	8.200	8.540

(U) The Scalable MMW Architecture for Reconfigurable Transceivers (SMART) program will develop an integrated, surface-emitting panel architecture for millimeter wave (MMW) transceiver arrays. The program will culminate in an objective demonstration of a large (at least 400 element), coherent, active electronically steerable array (AESA) achieving an output power density of $5W/cm^2$ and a total layer thickness of less than 1cm. Taken together, these values would represent a vastly greater "functional density" (e.g., power density, expressed in W/cm^3) than achievable with current MMW architectures, such as slats or bricks, without compromising performance in other areas (e.g., receiver noise figure). The 3-Dimensional (3-D) multi-layer modules that will be developed during the SMART program will greatly reduce AESA packaging complexity. Such compact, heterogeneously integrated, batch-fabricated, radio-frequency (RF) sub-array "building blocks" will be combinable to form arbitrarily large arrays. New capabilities, such as the ability to construct reconfigurable and/or multi-band AESAs and other MMW circuits,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

will be enabled by this architectural approach. This program will transition through industrial producers of MMW radar systems for DoD applications.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated multilayer wafer scale assembly and interconnect processes.
- Demonstrated beamforming-on-a-chip.
- Demonstrated 96GHz power amplifier at world-record 19.6 dBm.
- Four-layer thermal test coupon demonstrated with micro heat sink demonstrated 31 degrees centigrade per watt thermal resistance.

FY 2008 Plans:

- Achieve an integrated, sixteen element (4x4) transmit (only) millimeter-wave AESA with output power greater than 5W/cm² and thickness less than 10mm.
- Demonstrate in an anechoic chamber the ability to direct the beam.
- Initiate development of prototype receiver components.

FY 2009 Plans:

- Incorporate receive capability into the AESA while maintaining the thin dimension.
- Demonstrate high isolation between transmit and receive functions.
- Conduct evaluations and demonstrations of prototype components.
- Initiate development of integrated prototype receiver using digital and analog logic technologies.
- Initiate development of design automation algorithms and tools.

	FY 2007	FY 2008	FY 2009
DARPA Interference Multiple Access (DIMA) Communications	7.104	6.398	5.399

(U) The DARPA Interference Multiple Access (DIMA) Communications program will develop a networked radio system that supports voice and data. The goal of this program is a network that is dynamically controllable using techniques such as reconfiguration, optimum resource allocations based on mission priorities, and dynamic policies, as opposed to relatively passive reactions to changes by the commercial

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

infrastructure. This program will initially develop direct sequence spread spectrum (DSSS) communications technologies as a building block to enable robust, mobile, tactical wireless networks, which are the foundation for network centric warfare concepts. The fundamental technical challenges are scalability, multi-user detection processing, covertness, robustness and platform size, weight and power requirements. The DIMA Communications program will develop and demonstrate a system based on multi-user detection concepts that can take advantage of overloaded channels while operating in an environment absent of infrastructure (ad-hoc networked.) The technologies developed under this program are planned for transition to the Army and SOCOM in FY 2010.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed development of DIMA testbed.
- Researched and developed computational algorithms for the Multi-User Dimension (MUD) and Parameter Estimation (PE).
- Commenced design of a test package to support development and demonstration of the system.
- Initiated development of a suitable Media Access Control (MAC) for a MUD-based system.
- Initiated the system design to support a two Field-Programmable Gate Array (FPGA).

FY 2008 Plans:

- Complete development of multi-user PE.
- Complete development of DIMA Infrastructure Free Waveform/MAC.
- Demonstrate real-time DIMA on a COTS platform.

FY 2009 Plans:

- Reduce complexity of DIMA system.
- Develop test and demonstrate real-time DIMA on a handheld platform
- Begin transition of DIMA program to Army and SOCOM.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
Tactical Combined Fiber-Optical & Free-Space Edge Network	3.024	3.000	4.250

(U) Based on technologies developed under the Next Generation Optical Networks program (budgeted in PE 0602303E, Project IT-03), the Tactical Combined Fiber-Optical and Free-Space Edge Network effort will make it possible for the U.S. military to create a rapidly deployable, self-healing, tactical wavelength-division-multiplexed (WDM) fiber-optical network, combined with free-space optical and directed radio frequency (RF) networks, that can provide substantial communications capability to command centers deployed in somewhat mature areas of hostility. Key capabilities that will be enabled by this program include: (1) the elimination of power needs in the core of the network through the design and fabrication of passive wavelength-routing nodes that will allow the switching functions to be done via tunable optical transmitters and receivers (transceivers) at the edge of the network; (2) enhanced network survivability through a suitable highly connected network topology leveraging a fast-restoration protocol capable of rapid recovery from multiple network node and link failures; and (3) extended geographical coverage of the network to hundreds of kilometers, without requiring additional power at the core. In addition, protocols will be developed to enable the connection of this network to tactical wireless networks as well as to existing fixed networks allowing the efficient transmission of a combination of internet protocol (IP), digital video streams as well as analog and digital radar, electronic warfare (EW) and RF signals. The program will also include the development of techniques to realize ruggedized network nodes and interconnecting fiber cables, which are strung along the ground, buried in the ground and/or in riverbeds or other waterways. This program is expected to transition to the Army and Marines in FY 2011.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed a feasibility study for using a tactical fiber-optic network as an infrastructure to enable reliable wireless communications to warfighters deployed deeply in areas of hostilities.

FY 2008 Plans:

- Evaluate the processing needs and practical limitations of the network's wireless communications capability.
- Create a suitable architecture for a passive, WDM fiber-optical network with high connectivity for increased reliability.

FY 2009 Plans:

- Develop prototype wireless base stations and associated processing equipment to enable the network's wireless communications capability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- Demonstrate the ability to interconnect client devices with a wide range of analog and digital signal formats and protocols.
- Devise appropriate protocols to enable the integration of the network with existing networks and tactical wireless networks.
- Build and test a network testbed that is representative of tactical networks and environments.

	FY 2007	FY 2008	FY 2009
Wireless Network after Next (WNaN)	8.000	16.861	23.486

(U) The Wireless Network after Next (WNaN) program goal is to develop and demonstrate technologies and system concepts enabling densely deployed networks in which distributed and adaptive network operations compensate for limitations of the physical layer of the low-cost wireless nodes that comprise these networks. WNaN networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the nodes. The technology created by the WNaN network effort will provide reliable and highly available battlefield communications at low system cost.

(U) The WNaN program will develop a low-cost handheld wireless node that can be used to form high-density ad hoc networks and gateways to the Global Information Grid. This program will also develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. This program will culminate in a large-scale network demonstration using the multi-channel nodes. WNaN technology is planned for transition to the Army in 2011.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed architectural, functional, and electrical designs of the multi-channel WNaN radio that utilize high-volume, low-cost commercial-off-the-shelf (COTS) RF circuits narrowband tuning filters.
- Initiated the development of WNaN advanced networking technology.

FY 2008 Plans:

- Design, build, test, and demonstrate handheld/body wearable multi-channel WNaN radio that utilizes high-volume, low-cost COTS RF circuits narrowband tuning filters and dual-core digital signal process (DSP) baseband processing.
- Develop, integrate and test low risk and enhanced network technologies that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2009 Plans:
- Continue development, integration and testing of network technologies that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes.
- Demonstrate a communication system where the network layer can mitigate shortfalls in the physical layer.
- Commence demonstration of large-scale operation of 500 to 1000 nodes integrated into a highly adaptive, dynamic, self-forming, self-healing WNaN military network.
- Develop and test 100 advanced prototype WNaN radios in final production form factor.

	FY 2007	FY 2008	FY 2009
Networked Bionic Sensors for Language/Speaker Detection	0.000	1.500	2.950

(U) The Networked Bionic Sensors for Language/Speaker Detection program will develop and demonstrate low-power micro-sensor devices and networks for language/speech detection and recognition processing to detect voice activity, including speaker ID recognition in villages known to be insurgent recruitment “hot-spots”. The system will use ultra-low power signal conditioning/processing front-end processors with language/speaker recognition algorithms for distributed sensor network applications in the battlespace. Networked bionic sensors will be able to make detections within meters from the target providing high Signal to Noise Ratio ((SNR) of >10 dB) with sufficient recognition performance in an urban (non-telephonic) environment. This program will provide the ability to discretely monitor buildings, human presence detection/tracking in other sensitive areas, enable force protection, and provide Battle Damage Information. Intelligence, Surveillance, and Reconnaissance (ISR) capabilities can be enhanced with this technology by covertly detecting and tracking high-value targets with hand emplaced or air deployed sensor networks. The technology developed is planned for transition to the Marines in 2010.

(U) Program Plans:

FY 2008 Plans:
- Develop system architecture to exploit low-power micro-sensor devices and networks.
- Develop speech recognition algorithms.

FY 2009 Plans:
- Laboratory performance testing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM)	1.000	1.500	3.000

(U) The Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) project will pursue MIMO communication systems, which have the potential to increase data rates by 10-20 times above current systems. MIMO will use a multipath to create parallel channels in the same frequency band thereby increasing spectral efficiency. This effort will demonstrate the MNM capability under dynamic urban Non-Line-of-Sight multipath channel conditions where conventional techniques are degraded. Final efforts will culminate in the development of a wideband form-factor (Joint Tactical Radio System (JTRS) cluster 1 size PC card) system. MNM was previously funded in PE 0603764E, Project LNW-03. The MNM technology is planned for transition to the Army in FY 2010.

(U) Program Plans:

FY 2007 Accomplishments:

- Researched and designed variable bandwidth MIMO radio that can be reconfigured on a per-packet basis.
- Delivered and demonstrated first generation MNM node including mobility up to 70 mph.

FY 2008 Plans:

- Carry out field trials collecting data in diverse environments including urban, residential, littoral, and rural.
- Demonstrate multi-node MIMO operation.
- Demonstrate MAC-PHY interface that can be configured on a per-packet basis.
- Demonstrate wideband interference mitigation using various techniques.

FY 2009 Plans:

- Test an 8 node MNM radio network with baseline capability against the performance of a traditional single channel radio.
- Demonstrate energy aware link adaptation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
VPN for ADHOC Networks	0.000	0.000	2.000

(U) Tactical implementation of Virtual Private Network (VPN) requires operators to log into gateways in the Continental U.S. to connect to each other. Operators do not like this because it can reveal whom and where operators are located. This program will define VPN encryption requirements, limitations of field computing devices (FCDs), and employ recent breakthroughs in ad-hoc networking to enable tactical VPN connectivity. Operational requirements include the need for client-to-client VPN connectivity on FCDs with ad-hoc, peer-to-peer connectivity. Technical approaches to be explored include advanced ad-hoc-networking protocols coupled with small footprint VPN encryption standards. Potential technologies to be investigated include ad-hoc networking and peer-to-peer protocols and advanced encryption technologies to meet VPN standards. The system will enable covert operators to exchange mission-critical information while maintaining covertness in the field. This technology will transition to SOCOM in FY 2010.

(U) Program Plans:
FY 2009 Plans:
- Design VPN client-side software.
- Lab test the VPN software against measured data and security requirements.
- Harden code for field evaluation.

	FY 2007	FY 2008	FY 2009
Symbiotic Communications (SYCO)	3.337	0.000	0.000

(U) The Symbiotic Communications (SYCO) program developed an airborne passive radar system to enable precision targeting and battlefield situational awareness. SYCO generated high-resolution Synthetic Aperture Radar (SAR) imagery. This system operated passively and is effective in clear and adverse weather. SYCO has demonstrated a proof-of-concept through ground-based and airborne flight tests. Additionally, a design for a real-time prototype, as well as automated algorithms to enable real-time processing have been developed and ground tested. The SYCO airborne test-bed was modified for autonomous on-board real-time processing and image exploitation and flight-tested during FY 2007. To

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

complete this project, the test bed will be upgraded and flight tested in early FY 2008 with a conformal antenna, to demonstrate form/fit/function compatibility for transition. The SYCO technology is planned for transition for Service applications.

(U) Program Plans:
FY 2007 Accomplishments:
- Demonstrated real time on board processing and exploitation of SYCO imagery.
- Integrated conformal antenna and demonstrated performance.

	FY 2007	FY 2008	FY 2009
Connectionless Networking (CN)	5.580	0.000	0.000

(U) The Connectionless Networking (CN) program developed technology to allow networks (such as unattended ground sensors (UGS)) to send and receive messages without initial link acquisition or previous sharing of routing information. This improved energy usage per bit of delivered information by as much as 100 to 1,000 times compared to conventional and near-term deployable communications systems and allowed data to be collected more efficiently from high value, but energy limited sensors. Conventional radio link and network designs expend most of the energy on link establishment and maintenance, as well as packet and network overhead. This energy requirement not only limits the lifetime of energy-limited systems, it unnecessarily fills the radio spectrum, limiting available bandwidth, creates unnecessary risks of detection, and increases thermal loads. These impacts are particularly severe for communications with proliferated sensors, or remotely operated weapons. Eliminating the requirement to maintain a continuous network link enabled these platforms to provide continuous connectivity without consumption of power, or compromising emanations. The CN program exploited existing and available signal processing components, intelligent (processing and memory intensive) routing, and availability of situational information to demonstrate a total energy savings of at least 100 times typical connection oriented network applications. The CN technology is planning transition to the Special Operations Command, Army, Navy, and Marines for unattended ground sensors and low duty cycle applications.

(U) Program Plans:
FY 2007 Accomplishments:
- Fabricated interim radio frequency and digital boards for software development.
- Executed software and protocol development to incorporate highly adaptive operating modes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- Completed final board design and layout.
- Investigated transition opportunities to the USMC Tactical Remote Sensor System program.
- Finalized transition approach with Special Operations Command, Army, Navy and Air Force.
- Completed system integration and demonstrate energy efficient sensor networking in field experiments.
- Completed software and protocol development.

	FY 2007	FY 2008	FY 2009
SATCOM CX	2.950	0.000	0.000

(U) The SATCOM CX program developed a proof of concept system that enabled multiple users' access to 100 kilobits per second (kbps) SATCOM channels using the existing C-band satellite architecture. This new capability became possible, in part, by moving away from the existing paradigm regarding usage of these satellites. This SATCOM CX paradigm envisions satellites as merely a node or relay for a single user. In communications terminology, the satellite is part of a single-input/single-output (SISO) channel. Instead, this program considered multiple satellites simultaneously. Using this approach, a multitude of co-channel users send signals that illuminate a multitude of satellites. Powerful processing algorithms then isolate the individual communication links. Using the constellation in this manner provides signal gain and interference rejection.

(U) The increased complexity of the SATCOM CX communication link demands dynamic and adaptive network protocols to ensure optimal performance is achieved. The technologies developed under this program will transition to the Services' expeditionary forces.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated concept feasibility by using the space segment (C-band transponder) and transmission channel to provide sufficient stability to support the phase locked loop (PLL) operation required by the SATCOM CX forward link algorithms to maintain expected gains.
- Demonstrated a significant gain in the signal-to-noise-ratio (SNR) that can be achieved by coherently combining two C-band channels using the SATCOM-CX algorithm.
- Demonstrated full duplex real-time SATCOM CX operation using non-form factor demonstration hardware.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– Developed production and operational cost reduction roadmap and transition plan.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	36.658	19.642	0.000	0.000	0.000	0.000	0.000
Rapid Strike Force Technology LNW-01	17.304	19.642	0.000	0.000	0.000	0.000	0.000
Future Combat Systems LNW-03	19.354	0.000	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) The Land Warfare Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. This program will complete with FY 2008 funding and on-going efforts will continue in other program elements that fund technologies to support urban area operations.

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces, particularly in urban areas where both combatants and civilians are present. The Rapid Strike Force Technology project developed technologies that serve as force multipliers, enabling safe and effective operations in hostile environments.

(U) The U.S Army's Future Combat Systems (FCS) is a System of Systems (SoS), which will provide capabilities that strike an optimum balance between critical performance factors (e.g., operational and tactical mobility, lethality, survivability, and sustainability) and strategic responsiveness. The FCS program embraces an evolutionary acquisition, spiral development process. The Joint DARPA/Army activity supported the FCS spiral process through the development of critical technology improvements for FCS platform variants and the Network.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Land Warfare Technology; PE 0603764E

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	44.805	24.711	32.612
Current Budget	36.658	19.642	0.000
Total Adjustments	-8.147	-5.069	-32.612
Congressional program reductions	-7.000	-5.069	
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	-1.147		

(U) Change Summary Explanation:

FY 2007	Decrease reflects the SBIR/STTR transfer and the Section 8043 rescission.
FY 2008	Decrease reflects a PE execution adjustment and reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.
FY 2009	Decrease reflects re-prioritization, completion of several Urban Warfare efforts in Project LNW-01, Rapid Strike Force Technology, transfer of the balance of the urban warfare efforts to other, more suitable Program Elements, and completion of the Future Combat Systems project.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Rapid Strike Force Technology LNW-01	17.304	19.642	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces, particularly in urban areas where both combatants and civilians are present. This project is developing technologies that serve as force multipliers, enabling safe and effective operations in hostile environments. This project stems from the need to support the development of effective and adaptive weaponry, both lethal and non-lethal, for a variety of target suppression effects. Other technologies to be explored will include teleoperated systems, novel targeting and firing techniques, and advanced situational awareness and response systems. This project will complete with FY 2008 funding and on-going efforts will continue in other Program Elements that fund technologies to support urban area operations.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Multi-Modal Missile	3.400	7.000	0.000

(U) The Multi-Modal Missile program will explore the development of an integrated, networked man-portable weapon system capable of performing surface-to-surface, and surface-to-air missions with an emphasis on extreme precision. The program will focus on delivering precision targeting accuracy in both direct and indirect fire modes against multiple targets, and beyond line-of-sight functionality including: armored and soft ground vehicles, bunkers, personnel and helicopters, and UAVs. The Multi-Modal Missile is being developed to replace both the Javelin and TOW missiles with a single missile and be compatible with existing Javelin and TOW launch infrastructures. The objective capability will integrate a variety of existing weapons systems functions and provide both mounted and dismounted soldiers with an affordable compact system. Critical characteristics of this weapon system concept include lightweight, simple operation, and affordable. Technologies under consideration will include advanced imaging seekers precision terminal guidance, propulsion, power storage, vertical launch with lock-on-after-launch

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

capability, and novel warhead concepts to support a wide range of engagement geometries with desired lethality effects against a range of targets. Beginning in FY 2009, this program will be funded in PE 0603286E, Project AIR-01.

(U) Program Plans:
FY 2007 Accomplishments:
- Performed initial system design analyses and trade off studies.

FY 2008 Plans:
- Initiate critical technology, maturation efforts for seeker, propulsion, guidance and warhead.

	FY 2007	FY 2008	FY 2009
Non-Lethal Alternatives for Urban Operations	2.200	2.268	0.000

(U) The Non-Lethal Alternatives for Urban Operations effort is exploring system concepts and enabling technologies for non-lethal weapons in challenging urban and semi-urban environments. This effort will assess effects, targeting systems, delivery systems, and countermeasures, and will develop integrated less-lethal system options for application to urban warfighting. Effects being investigated include less-lethal projectiles, malodorants, entanglers, and marking agents. The effort is considering direct and indirect fire systems to counter personnel and to provide area effects against vehicles, crowds and groups of combatants. Operating scenarios being explored include force protection for fixed sites, force protection for mobile forces, situational control (including traction control), individual soldier weapons, border protection, and protection of extended infrastructure. The effort will pay particular attention to technologies that support application on autonomous and teleoperated unmanned ground robotic vehicles in urban environments at a sustained operational tempo. Transition organizations will be the United States Air Force and the National Reconnaissance Office, Special Operations Command, the Army Corp of Engineers' Engineering Research and Development Center, and others may be identified as efforts and systems are developed.

(U) Program Plans:
FY 2007 Accomplishments:
- Performed initial concept development and effects assessments.
- Developed initial urban less-than-lethal system designs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

- Developed initial reversible chemical formulations for significant traction reduction on rough surfaces.
- Identified and modeled means for asymmetric mobility.

FY 2008 Plans:

- Conduct less-than-lethal technology maturation efforts to address and reduce system risk.
- Research and develop prototype chemical system that reversibly denies adversary mobility (people and vehicles) by modifying ground traction, with simultaneous retention of friendly force mobility.
- Refine mobility control formulations and develop delivery systems.

	FY 2007	FY 2008	FY 2009
Tactical Urban Operations (TURBO)	0.425	0.000	0.000

(U) The Tactical Urban Operations (TURBO) program sought to provide dismounts with integrated information from low-level airborne assets, such as the Micro Air Vehicle (MAV) or the Organic Air Vehicle (OAV), local intelligence sources, and responsive and improved fires/effects capable of acting on this information. Technologies explored included: aggregation of information from multiple MAVs and OAVs with other sources into an easy-to-use interface; improved techniques for detecting dismounted targets and distinguishing friend from foe; and improved methods for displaying information to dismounts and allowing them to direct operations without impeding their mission.

(U) Program Plans:

FY 2007 Accomplishments:

- Identified system architecture and constraints based on MAV Advanced Concept Technology Demonstration experience.

	FY 2007	FY 2008	FY 2009
PEO-Soldier/Exoskeleton Transition	6.000	0.000	0.000

(U) The PEO-Soldier Exoskeleton Transition program employed novel mechanisms, information systems, and power management hardware and software to ultimately produce a wearable machine that will serve as an intuitively operated load carriage system for individuals. The goal of

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

the program was to enable an individual soldier to lift and carry 150 pounds while feeling only a small part of the load, work for long periods of time, and to travel in difficult conditions. This ability for a single soldier to carry heavy loads could be leveraged in applications ranging from moving boxes of ammunition or supplies to enabling the carriage of significantly greater body armor than is presently possible. This program transitioned to the Army.

(U) Program Plans:
FY 2007 Accomplishments:
- Developed the enabling components and improved the overall system performance of the exoskeleton device against threshold requirements.
- Transitioned program to Army for continued development and solider evaluations.

	FY 2007	FY 2008	FY 2009
Concealed Weapons Detection	2.330	3.500	0.000

(U) The Concealed Weapons Detection program will explore various phenomenologies for concealed weapons detection. Imaging based approaches will be developed utilizing an integrated silicon-based antenna array receiver device to produce whole radar arrays on a single die. Advanced front-end lens/reflector subsystems composed of lightweight, low cost materials must be developed in conjunction with highly sensitive receiver subsystems to extend the stand-off range. Alternative sensor approaches are also being explored to provide a multi-mode, multi-sensor solution targeted at improved discrimination. These approaches will incorporate X-ray, THz, and millimeter wave radar to provide multispectral tomographic capability. Specific dielectric properties at various electromagnetic frequencies will also provide measurable fingerprints for material classification. High-performance, real-time image processing algorithms must be executed in real-time and require the development of a lightweight, low-power processor. This novel concealed weapons detection system could result in a significant reduction in military and civilian casualties. The concepts and technology will continue in PE 0603767E, Project SEN-01.

(U) Program Plans:
FY 2007 Accomplishments:
- Demonstrated dielectric spectroscopy techniques in very near field applications.
- Developed sensor fusion algorithms for registering disparate sensor outputs and integrating their results.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

FY 2008 Plans:
- Conduct conceptual verification to determine qualitative performance achievable of stand-off imaging detection.
- Develop candidate conceptual designs meeting objective system performance.

	FY 2007	FY 2008	FY 2009
Asymmetric Materials for the Urban Battlespace	2.149	4.874	0.000

(U) The Asymmetric Materials for the Urban Battlespace program will investigate a novel class of materials that, either by themselves or as part of a system, provide asymmetric capabilities in visible signatures, ballistic/fragment/blast protection, and personnel transport. Friendly forces will be able to see through it and shoot through it, but hostile forces will not. Asymmetric, or "one-way," materials will support basic unit operations such as raids, cordon and search activities, snap checkpoints, and fire fights. Significant technical obstacles include the design and fabrication of composite or meta-materials with true one-way capabilities, including the ability to "self-heal" if necessary. The materials must be lightweight, respond instantly, and be easy to deploy and retract in confined spaces. Potential transition partners include SOCOM, Army, and Marines.

(U) Program Plans:

FY 2007 Accomplishments:
- Explored material architectures appropriate to the design concept.

FY 2008 Plans:
- Develop and integrate material components and architectures for laboratory testing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

	FY 2007	FY 2008	FY 2009
Deep Speak	0.800	2.000	0.000

(U) The Deep Speak program is developing new networking, coding, and waveform techniques that enable communications signals to penetrate the surrounding buildings and underground facilities. This will maintain the warfighters' links to each other and the global network, magnifying our striking power.

(U) Predictive networking techniques that use current position and velocity information to predict future network topologies will reduce the number of broken links by 98%. By breaking the communications waveform into multiple layers, each encoded at a different quality and energy per bit of information (E_b/N_0), it is possible to reduce the sensitivity of the communications system to the unpredictable shadowing and fading that occurs in urban environments. For voice transmissions multi-layer waveforms will reduce the transmit energy required by 5 decibel (dB), and for video by 7 dB while still ensuring that the transmission is comprehensible. Finally, synthetic speech encoding techniques will vastly reduce the data rate required for transmitting speech, and thus has the potential to increase the signal level at the receiver tenfold. The program is planned to transition to the Army in FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed multi-layer waveforms and demonstrated (through simulation) that they are much more efficient than conventional waveforms for video transmission and at 5 dB more efficient for speech transmission.
- Developed a phoneme based synthetic speech encoder/decoder and demonstrated that cooperative tasks can be accomplished using the synthetic speech encoder/decoder.

FY 2008 Plans:

- Develop predictive network techniques and demonstrate (through simulation) a significant reduction in the number of broken links in an urban networking environment.
- Demonstrate predictive networking, multi-layer waveforms and synthetic speech encoding technologies in typical urban environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

(U) Other Program Funding Summary Cost:

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Classified DARPA Programs PE 0603765E, Project CLP-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	147.159	186.992	196.697	162.551	178.319	188.225	188.223
Classified DARPA Programs CLP-01	147.159	186.992	196.697	162.551	178.319	188.225	188.223

(U) Mission Description:

(U) This program element funds Classified DARPA programs. Details of this submission are classified.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Classified DARPA Programs	147.159	186.992	196.697

(U) Program Plans:

FY 2007 Accomplishments:

– Details will be provided under separate cover.

FY 2008 Plans:

– Details will be provided under separate cover.

FY 2009 Plans:

– Details will be provided under separate cover.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Classified DARPA Programs PE 0603765E, Project CLP-01

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	151.025	188.188	210.801
Current Budget	147.159	186.992	196.697
Total Adjustments	-3.866	-1.196	-14.104
Congressional program reductions	0.000		
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	-3.866		

(U) **Change Summary Explanation:**

FY 2007 Decrease reflects the SBIR/STTR transfer.

FY 2008 Decrease reflects Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.

FY 2009 Justification for the decrease is contained in the classified submission.

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

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Network-Centric Warfare Technology; PE 0603766E

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	137.063	150.677	156.733	220.952	206.504	206.362	210.068
Joint Warfare Systems NET-01	46.792	75.093	69.133	54.954	56.124	58.105	61.076
Maritime Systems NET-02	25.853	25.706	30.471	61.083	63.238	61.511	62.247
Classified NET-CLS	64.418	49.878	57.129	104.915	87.142	86.746	86.745

(U) Mission Description:

(U) The Network-Centric Warfare Technology program element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to develop and rapidly mature advanced technologies and systems required for today's network-centric warfare concepts. It is imperative for the future of the U.S. forces to operate flawlessly with each other, regardless of which services and systems are involved in any particular mission. The overarching goal of this program element is to enable technologies at all levels, regardless of service component, to operate as one system.

(U) The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly expanded capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents utilizing systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often collocated, and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required.

(U) The Maritime Systems project will identify, develop and rapidly mature critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Naval forces play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E

provide both rapid strike and project sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces.

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	163.755	151.641	181.971
Current Budget	137.063	150.677	156.733
Total Adjustments	-26.692	-0.964	-25.238
Congressional project reductions	-22.500	-0.964	
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	-4.192		

(U) Change Summary Explanation:

FY 2007	Decrease reflects the Section 8043 Recission and the SBIR/STTR transfer.
FY 2008	Decrease reflects reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.
FY 2009	Decrease reflects program completion of Quarantine Toxic UAV Payloads, Confirmatory Hunter Killer System, and Urban Operations Hopper in Project NET-01 and rephasing of the Tango Bravo program to MOA requirements in Project NET-02.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Joint Warfare Systems NET-01	46.792	75.093	69.133	54.954	56.124	58.105	61.076

(U) Mission Description:

(U) The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly expanded capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents using systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often co-located, and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required. This project supports all levels of the force structure including: (1) the strategic/operational level by generating targeting options against opponents' centers of gravity that have complex networked relationships; (2) the tactical/operational level by managing highly automated forces with tight coupling between air and ground platforms; and (3) the focused tactical level by developing platforms, which acquire targets of opportunity, cuing network-based analysis of likely enemy operations and developing warfighter tools, thus maximizing the presence of ground forces in stability and support operational environments.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Federated Object-level Exploitation (FOX)	7.000	11.000	18.456

(U) The Federated Object-level Exploitation (FOX) thrust will provide a new set of geospatial intelligence (GeoINT) products, continuously updated and maintained in a form that ensures their consistency across both product elements (digital elevation models, traditional maps, 3-D structure models, census summaries, and directories) and spatial nodes (coarse resolution country data for economic analysis to fine resolution

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

building data for platoon-level combat operations). Included programs will combine techniques including model-based image analysis (both object recognizers and change detectors), symbolic correlators (both temporal and spatial), and emerging cognitive methods to identify changes to objects, addresses, names, and functions of natural and man-made structures. These algorithms will be scaled to operate on data streams including full-motion video, ladar, text, and tabular data, in addition to conventional geospatial imagery. Federated algorithm architectures will be explored to achieve scalability through spatial, temporal and ontological partitioning. FOX technologies are planned for transition to the National Geospatial-Intelligence Agency.

- The Auto Metadata Extractions effort will build a system to automatically (with no man-in-the-loop) extract metadata from terabytes of multi-sensor imagery and signals per day. Extracted metadata will include both platform generated information (classical metadata) and algorithmically extracted features and internals. The extracted metadata will be (1) produced in a unified framework, and (2) sufficiently semantically rich to support both semantic information fusion and development of multi-dimensional predictive models. The system will provide all of the fundamental extracted data required for advanced exploitation technology development.

- The Exploitation Language Technology for GeoINT program will build a system to extract and linguistically confirm terms and labels of geographic significance from graphical, textual and audio sources. The program will develop the technology to associate and verify the extracted information against features extracted from imagery. Both extraction and association will be performed against and across multiple languages. A major effort will be made to develop necessary database and query technology to support a wide range of GeoINT specific concepts, e.g., feature classes, complex distance calculations, and boundaries.

- The All Things Repository effort will develop a system capable of ingesting 400 terabytes of multi-sensor all-source imagery, Moving Target Indicator (MTI) and signals per day. The program will build a fully automated metadata and features extraction framework to process all incoming data, and develop the distributed very-large database technologies required to provide both the raw sensor data and extracted features data to a multi-level exploitation user community, both human users and automated agents. Work-flow aware data transformation, data aggregation and data caching technologies will be developed to rapidly provide the user with access to the correct subset of the data rapidly and at appropriate bandwidth.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

(U) Program Plans:

– Auto Metadata Extractions
FY 2007 Accomplishments:
-- Demonstrated processing infrastructure to automatically index all-source imagery.
FY 2008 Plans:
-- Demonstrate assimilation of location, shape and class data into unified representation.
FY 2009 Plans:
-- Demonstrate temporal queries of geospatial data.

– Exploitation Language Technology for GeoINT
FY 2008 Plans:
-- Preliminary design review of prototype.
FY 2009 Plans:
-- Demonstrate dynamic extraction of urban geospatial information from available documents.

– All Things Repository
FY 2007 Accomplishments:
-- Initiated concept development review.
FY 2008 Plans:
-- Demonstrate Rapid Archive Geospatial Data.
FY 2009 Plans:
-- Demonstrate integration with imaging intelligence products.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

	FY 2007	FY 2008	FY 2009
Network Command	9.197	9.393	8.000

(U) The Network Command program leverages recent advances in network computing to dramatically improve collaboration among physically separate command posts. The program allows commanders and their staffs to share situation information, develop coordinated battle plans, generate and compare alternate courses of action, and assess likely outcomes, without conventional group briefings. Network Command builds on the paradigm established by the Command Post of the Future program, which demonstrated to commanders, working with voice-over-internet protocol (VOIP) and robust graphical collaboration software, a coherent understanding of a situation and operational plan without any face-to-face interactions.

- The Network-Centric Situation Assessment program develops and deploys technologies to assess military situations at levels of interest above individual targets. The program uses all-source data to reconstruct unit organizations, mission relationships, logistics connections, and communications connectivity and analyzes data over time to infer movement, communication, and supply patterns. Within this context, capability analyses are provided and future courses of action are hypothesized. The objective is to understand potential capabilities and intentions of opposing forces. This effort provides greater understanding of opponents' force structures, capabilities, and operational practices, and then enables commanders to sustain effects-based targeting rather than simple attrition strategies. The program provides a context for discovering vulnerabilities in opposing forces and provides cues for intelligence, surveillance, and reconnaissance planning, as it suggests areas of future enemy activity that merit intense scrutiny. Technologies are planned to transition to the U.S. Army Distributed Common Ground Station.

- The Joint Mission Rehearsal program integrates high-fidelity; mainframe-based combat simulations with situation assessment and planning tools. The objective is to allow rehearsal of joint missions, while participants are en route to operations or remain at their home stations. The program uses current situation data to: (1) provide initial conditions for the simulations, and (2) plan data to steer the dynamics of the simulations along the selected courses of action. The technology streams data from the simulations for display, then visualization systems are available to the prospective participants. The visualization permits the warfighter to interact with the simulation in a manner consistent with their anticipated role in the mission being rehearsed. The program delivers the capability to practice and fine-tune mission plans for joint military operations and enables commanders and staff to participate from their current location instead of a

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

training facility, thereby reducing deployment needs while improving mission planning and effectiveness. Technologies are planned to transition to the U.S. Army Simulation, Training & Instrumentation Command.

(U) Program Plans:

– Network-Centric Situation Assessment
FY 2007 Accomplishments:
-- Identified data fields available to a representative theater commander.
FY 2008 Plans:
-- Evaluate technologies using real-world data.
FY 2009 Plans:
-- Transition software components to U.S. Army Distributed Common Ground System.

– Joint Mission Rehearsal
FY 2007 Accomplishments:
-- Identified testbed and avatar requirements.
FY 2008 Plans:
-- Demonstrate insertion of moving avatars into Helmet Mounted Display.
FY 2009 Plans:
-- Demonstration of dynamic avatar simulation insertion in Army Training Exercise.

	FY 2007	FY 2008	FY 2009
Precision Urban Combat Systems (PUCS)	7.665	6.400	6.000

(U) The Precision Urban Combat Systems (PUCS), including the Remote Detection of Suspicious Vehicles (RDSV) programs are developing and validating advanced sensor, exploitation, networking, and battle management capabilities for joint dismounted forces in urban combat. These programs include detection and tracking of potential enemy targets, discrimination and identification of friendly versus enemy units, sorting of enemy from neutral and non-combatant personnel, coordination of sensing, maneuver, and fires, and continuous assessment of results. PUCS and RDSV will utilize technologies including: smart networks of distributed imaging and non-imaging sensors; sensors with the capability to detect

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

hidden human targets; improved 3-Dimensional (3-D) visualization systems, and multi-spectral discrimination systems that survey the battlefield for weapon activity and detect primary signatures. These capabilities will be developed within the framework of both legacy forces and expected future forces. The program will provide a set of prototype demonstrations of the capabilities in surrogate urban combat environments. Technologies are planned to transition to the U.S. Special Operations Command and the Marines.

- The Smart Dust Sensor Networks Applied to Urban Area Operations program will provide persistent staring reconnaissance, surveillance, and target acquisition of the 3-D urban battlespace using a dense network of ground sensors. The system concept consists of ubiquitous and inconspicuous low-power, small and easily concealed ground sensors distributed throughout the urban landscape. The program includes the development of ultra small sensor nodes for easy deployment and concealment in a crowded urban environment and data fusion algorithms to exploit the abundance of new information provided by a dense urban spatial network. The program will create a self organizing system that will integrate and exploit reliable networks of low-cost, small, and long-lifetime sensor nodes providing the capability for monitoring secured areas (e.g., buildings) and providing situational awareness to warfighters (e.g., checkpoints and sniper fire), and intelligence applications such as wide-area persistent surveillance of roadways and major arteries (e.g., for Improvised Explosive Devices (IED) emplacement), perimeters, and even city wide areas. The program technologies will transition to the Army.

- The Exploiting Vibrations to Monitor Activities in Buildings program will develop procedures and sensors to characterize activity inside structures based on acoustic/seismic information. The types of information sought include number and location of personnel, foot traffic, operation of building mechanicals (ventilation, cooling, and heating; plumbing; etc.) as an indicator of human activity, operation of other machinery, door openings and closings, and speech. Algorithms that infer internal layout of the building from the pattern and location of these activities will be investigated along with the fusing of the information from other surveillance information gained by other sensing modalities.

(U) Program Plans:

– Smart Dust Sensor Networks Applied to Urban Area Operations
  FY 2007 Accomplishments:
  -- Prototyped miniaturized sensors based on dense ground sensor concept.
  -- Developed self organizing network algorithms.
  -- Estimated precise node locations and orientations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

FY 2008 Plans:
-- Complete algorithm evaluations and down select.
-- Demonstrate key performance parameters in field tests.

– Exploiting Vibrations to Monitor Activities in Building
FY 2007 Accomplishments:
-- Collected acoustic/seismic data from a set of sample buildings.
FY 2008 Plans:
-- Develop and evaluate candidate algorithms and down select.
FY 2009 Plans:
-- Develop and demonstrate technologies to separate targets from background.
-- Demonstrate at a representative military base.

	FY 2007	FY 2008	FY 2009
Urban Ops Hopper*	3.000	4.200	0.000

*Previously this was part of PUCS.

(U) The Urban Ops Hopper program will develop a semi-autonomous hybrid hopping/articulated wheeled robotic platform that could adapt to the urban environment in real-time and provide both surgical lethality and/or Intelligence, Surveillance, and Reconnaissance (ISR) to any point of the urban jungle while remaining lightweight, small and expendable to minimize the burden on the soldier. In general, small robots or unmanned ground vehicles (UGV) are severely limited by obstacle negotiation capability. The demonstrated hopping capability allows small UGVs to overcome obstacles 40x-60x their own size. Hopping will extend robot navigation to six degrees-of-freedom situational location and mapping. Hopping mobility can be shown to be five times more efficient than hovering for obstacles at heights less than or equal to ten meters. The proposed hopping robot would be truly multi-functional in that it will negotiate all aspects of the urban battlefield to deliver ISR and/or lethal payloads to non-line-of-sight targets with precision. The articulated wheel design allows the robot to negotiate short-range obstacles for precision placement in difficult terrain. This program will transition to Special Operation Forces in FY 2009.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated required hop height and length to meet current urban combat obstacle clearance.
- Demonstrated autonomous navigation in urban environment using baseline sensor suite.

FY 2008 Plans:

- Develop 3-D ISR obstacle detection, classification, and mapping tools for an unknown environment.
- Demonstrate autonomous navigation in urban environment using upgraded sensor suite.
- Develop precision hopping through restricted pathways to include windows and stairwells.
- Demonstrate precision hopping using upgraded mechanical articulated wheel design.
- Evaluate technologies in various Military Operations on Urban Terrain (MOUT) facilities.

	FY 2007	FY 2008	FY 2009
Multipath Exploitation Radar (MER)*	0.000	4.000	8.000

*Previously funded as the Total RF Detection and Ranging (TORDAR) system as part of PUCS.

(U) The Multipath Exploitation Radar (MER) program will address radar deficiencies due to discontinuous bandwidth: reduced range coverage, denial in certain geographic regions, interoperability issues, and reduced range resolution. This will involve a system-wide redesign of radar optimized over the full RF spectrum, not individual stove-piped tasks. It will include the integration of sparse bandwidth returns (including passive signals of opportunity), adaptive transmitter and waveform diversity, and agile frequency diverse hardware. Another key area that can be exploited is urban multipath. This program will exploit multipath bounces to detect and track moving targets within urban canyons, and extend the area coverage rate of airborne sensors by a factor of ten or more over physical line-of-sight limits. If successful, the urban coverage improvement will make it cost effective to consider airborne surveillance of an area the size of a large metropolitan area with a handful of airborne sensors. This capability will facilitate both manned and unmanned airborne Intelligence, Surveillance and Reconnaissance (ISR) and is planned to transition to the Air Force and Army in 2011.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

(U) Program Plans:

FY 2008 Plans:

- Develop improved tracking concepts to exploit multipath signatures in improving target localization and tracking.
- Demonstrate vehicle detection using urban multipath to extend radar sensing range in urban environment by a factor of three beyond line of sight limitations.

FY 2009 Plans:

- Perform passive bistatic measurements using common RF transmissions as radar signals of opportunity.
- Demonstrate urban clutter nulling capabilities from both stationary and moving airborne collections.
- Demonstrate factor of ten improvement in urban tracking using multipath radar.
- Perform measurements using integrated passive/active radar architecture.
- Develop urban tracking algorithms exploiting urban multipath.

FY 2009 Plans:

- Develop persistent wide-area surveillance architecture for large metropolitan areas.

	FY 2007	FY 2008	FY 2009
Multi Dimensional Mobility Robot (MDMR)	5.240	5.000	1.000

(U) The Multi Dimensional Mobility Robot (MDMR) program will investigate concepts using serpentine mobility to achieve new ground robot capabilities for search and rescue applications. The MDMR system will navigate complex urban terrain and provide the operator with real time images of its environment. Examples of the capability include: overcoming obstacles that are a significant fraction of its length, crossing slippery surfaces, ascending poles, climbing steep slopes, and optically sensing its immediate surroundings. The MDMR platform will be able to support a variety of search missions in hazardous environments such as urban rubble piles. To achieve such a degree of mobility, design concepts must address system challenges such as: on board power management; situational awareness; complex terrain navigation; and system controls. The technology is planned for transition to SOCOM.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

(U) Program Plans:

FY 2007 Accomplishments:

– Demonstrated serpentine mobility from a base level approach.

FY 2008 Plans:

– Develop smaller, more maneuverable serpentine platform.
– Develop and test tele-operation control.
– Develop and test sensors for integration onto the serpentine platform.
– Perform rigorous testing to characterize system performance.

FY 2009 Plans:

– Demonstrate and transition system to search and rescue users.

	FY 2007	FY 2008	FY 2009
Seismic/Acoustic Vibration Imaging (SAVI)	4.972	12.000	12.206

(U) The Seismic/Acoustic Vibration Imaging (SAVI) program will develop the capability to locate both near-surface tunnels and landmines with active seismic and acoustic sources. These systems will employ well characterized seismic and acoustic sources to stimulate the targets of interest from a remote platform. The interaction of the near surface seismic waves with tunnels and other objects will be observed with a multi-pixel laser interferometer system and used to assess the depth and extent of the targets in the midst of natural and man-made clutter. Similarly, focused acoustic sources will be employed to remotely stimulate plastic or metal antipersonnel and antitank mines. A laser interferometer system will be used to detect the resonant characteristics of the mines to discriminate against natural sources of clutter. The systems developed under this effort will be tested against a wide variety of soil types and environments to support operations under a wide range of conditions. Upon successful development of the initial and objective systems, the capabilities will be transitioned to the Army and Marine ground forces for the development and employment of operational systems starting in FY 2011.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

(U) Program Plans:

FY 2007 Accomplishments:

- Completed analysis of potential system requirements suited to meet the objectives of the mobile landmine and tunnel detection missions from a sensitivity and area search rate perspective.
- Initiated development of active acoustic sources for landmines, active seismic sources for tunnels, and multi-pixel laser vibrometer with variable field-of-regard used to make measurements.

FY 2008 Plans:

- Complete the preliminary reviews for the scalable system meeting the initial sensitivity and search rate objectives.
- Initiate and demonstrate the technologies required for the laser interferometer system, including the sources and sensors, as well as the mobile seismic and directional acoustic sources.
- Complete the operationally relevant test scenario for scalable system demonstration.
- Determine location for outdoor-scaled system demonstration and initiation of site preparation.

FY 2009 Plans:

- Complete the development of the component technologies required by the scalable system demonstration.
- Complete an outdoor demonstration of the active acoustic landmine detection and active seismic tunnel detection coupled with the scalable multi-pixel laser vibrometer system.
- Initiate the development of the scalable brassboard system for mobile operations.
- Scale the system to form-factored prototype and verify performance at suitable outdoor ranges.

	FY 2007	FY 2008	FY 2009
Human-carried Explosive Detection Stand-off System (HEDSS)	4.000	5.000	7.000

(U) Insurgent and terrorist elements are increasingly relying on human carried explosives because they are nearly impossible to visibly detect. The goal of the Human-carried Explosive Detection Stand-off System (HEDSS) program is to develop a system that can rapidly identify human-carried explosives (HCEs) at a stand-off range between 50 and 150 meters (m). While alternative technologies exist for HCE detection, they necessitate close-in sensing, are expensive and require extended processing times. Successful development of a HEDSS with detection ranges of

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

50 – 150 m will provide reliable protection for deployed forces from suicide bombers by allowing enough time and space to interdict bombers before they cause maximum damage. The technology is planned for transition to the Army and Marines.

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted proof-of-concept experiments and performed system level analysis designed to validate key technical assumptions and identify major system design parameters.

FY 2008 Plans:

- Design prototype system.
- Build and integrate system and conduct lab experimentation.

FY 2009 Plans:

- Conduct extensive field-testing of the system under expanded threat conditions.

	FY 2007	FY 2008	FY 2009
Sensing and Patrolling Enablers Yielding Enhanced Security (SPEYES)	1.237	4.100	0.000

(U) The Sensing and Patrolling Enablers Yielding Enhanced Security (SPEYES) program provides technologies for Stability and Support Operations (SASO) to enhance the capabilities of our current ground forces in Iraq and Afghanistan. The first program phase evaluates and inserts mature advanced ground-based C3I technologies for three problem areas (Fixed Site Security, Patrolling, and Cordon & Search), seeking to effect a significant force-multiplier improvement through transformational Tactics, Techniques, and Procedures (TTPs). Key Component Technologies include: 1) WASP Micro UAV, 2) Eye Ball R1 Throwable Camera, 3) Leave Behind Intrusion Detection Sensor, 4) SPEYES Handheld PDA Device, and 5) Vehicle Weight Analysis Software and Video/EOD Underbody Sniffers. Later program phases will develop technology to enable mobile and real-time data analysis to support dismounted soldier patrolling urban areas. The program will include (1) networked mobile devices, communicating new information to a local headquarters, and displaying analysis of the newly collected data; (2) headquarters-level automated real-time analysis of the current state of the observed network to identify gaps in the knowledge base, and generate additional information requests. Elements of the technology are under consideration for transition to the Army and Marines.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

(U) Program Plans:
FY 2007 Accomplishments:
- Integrated three devices on a common wireless network.
- Selected and demonstrated handheld computing device as an integration platform.
- Completed extensive training and deployment to Afghanistan.

FY 2008 Plans:
- Define system requirements.
- Develop and test system components.

	FY 2007	FY 2008	FY 2009
Effects Based Network Targeting	3.500	5.000	5.471

(U) The Effects Based Network Targeting program is developing technology to identify, determine vulnerabilities, target, and anticipate workarounds in enemy networks. These techniques use all-source information to continuously update models of urban networks. Using the models, operational objectives for urban interventions, expressed in terms of desired and undesired effects will be generated. The technology will then use these objectives to find vulnerabilities in the networks, nominating targets for prosecution to maximize desired effects while minimizing undesired effects. Further, the program will develop techniques for predicting those observables that will rapidly identify an opponent's response when several courses of action are available. In particular, the program will focus on radio frequency networks: identifying transmitters, receivers, and links between them. The program will apply advanced beam forming technologies to provide co-channel interference cancellation for densely deployed cellular telephone or WiFi services in an urban environment. From this understanding of the network topology, courses of action for precision jamming or flooding attacks can be assessed, including determination of effects on downstream components (subscribers to the network). Technologies are planned to transition to the U.S. Strategic Command.

(U) Program Plans:
FY 2007 Accomplishments:
- Demonstrated feasibility in naval tactical wargame.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

FY 2008 Plans:
- Demonstrate tools to analyze single networks.

FY 2009 Plans:
- Demonstrate tools to analyze combinations of networks, simulated inputs.

	FY 2007	FY 2008	FY 2009
Confirmatory Hunter Killer System - CCLR	0.981	7.000	1.000

(U) The Confirmatory Hunter Killer System - CCLR program is developing a low cost expendable loitering weapon/unmanned air vehicle for deployment in urban environments. The program is developing a hand-held, tube-launched, fiber-optic guided, loitering munition suitable for non-line-of-sight (NLOS) target prosecution by individual warfighters in urban environments. It will be an agile NLOS weapon that extends the warfighters' zone of engagement from 200 meters line-of-sight to 2000 meters NLOS. The guided munition will be capable of striking targets from significantly expanded avenues of approach, e.g. over the tops of buildings and around corners, at a distance of up to ten blocks depending on the specific terrain and building features. This program is planned for transition to the Army in 2008.

(U) Program Plans:

FY 2007 Accomplishments:
- Developed a tube-launched, compact, precision munition with warfighter-in-loop targeting and control via fiber optic link.
- Conducted risk reduction component tests.
- Verified launch, cruise and terminal mode performance.
- Conducted integrated system flight tests.

FY 2008 Plans:
- Perform risk reduction flight test.

FY 2009 Plans:
- Transition program to the Army.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

	FY 2007	FY 2008	FY 2009
Legged Squad Support System (LS3)	0.000	0.000	2.000

(U) The Legged Squad Support System (LS^3) program will explore the development of a mission-relevant tetrapod platform scaled to unburden the infantry squad and hence unburden the soldier. Soldiers in current operations carry upwards of 50lbs of equipment and in some cases 100lbs, over long distances and in terrain not always accessible by wheeled platforms that support infantry. As a result, the soldier's combat effectiveness can be compromised. LS^3 will leverage technical breakthroughs of prior biologically inspired legged platform development efforts. It will develop system designs to the scale and performance adequate for infantry squad mission applications, focusing on endurance, payload, terrain negotiation, and human-machine interaction capabilities, as well as secondary design considerations, such as acoustic signature. Multiple technical approaches will be explored, including electromechanical and hydraulic methods of legged actuation. Anticipated service users include the Army, Marines and Special Forces.

(U) Program Plans:
FY 2009 Plans:
- Develop, analyze and assess initial Legged Squad Support System preliminary designs.

	FY 2007	FY 2008	FY 2009
Quarantine Toxic UAV Payloads	0.000	2.000	0.000

(U) The Quarantine Toxic UAV Payloads program will develop a system which can safely and effectively sequester (entomb) toxic chemical and biological agent payloads located on hostile force unmanned aerial vehicles. While technology for detection, tracking, and destruction of these platforms exists, the destruction step is problematic since the process can inadvertently disperse the toxic agent over the intended (or other) targets. A means for safely, effectively, and inexpensively sequestering chemical payloads, and transporting these payloads to the ground, is a critical need. This program focuses on the development of a system, which integrates the tracking and detection capabilities with gentle methods of entombment (i.e., quarantine) of the active agent. Potential transition targets include SOCOM, Army, and Marines.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-01

(U) Program Plans:
FY 2008 Plans:
- Develop strategies and system architecture for entombment of UAV-borne chemical and biological agents.
- Develop materials and delivery techniques.
- Perform laboratory and field tests to demonstrate system capabilities.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-02

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Maritime Systems NET-02	25.853	25.706	30.471	61.083	63.238	61.511	62.247

(U) Mission Description:

(U) The objective of the Maritime Systems project is to identify, develop and rapidly mature critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Improvements in communications between and among submarines, surface ships and naval aircraft have allowed these forces to operate seamlessly with each other and with other Service's network centric systems. Naval forces will play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to provide both rapid strike and project-sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Persistant Ocean Surveillance (includes Surface Wave Harvesting)*	5.904	3.463	2.250

*Previously funded under Mobile Undersea Distributed Systems (MUDS).

(U) The Persistent Ocean Surveillance program combines geolocation techniques such as the global positioning system with station keeping and intra-sensor communication technologies to provide long-term station keeping ocean environment sensing buoys. These technologies, when applied with state-of-the-art undersea warfare sensors, will result in a floating field of smart sensors capable of observing the undersea environment in an area, including the presence of submarines and other undersea vehicles. A range of technologies have been considered including those that rely on the local environment (such as wind, ocean waves, solar energy, temperature differentials, etc.) for their power, miniature geolocation technologies, and technologies for sensor data storage, transmission, and intra-field communications. Persistent Ocean Surveillance-Station Keeping technology is planned for transition to the Navy in late FY 2009.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-02

(U) Program Plans:

FY 2007 Accomplishments:

- Completed design concepts for harvesting energy from the local environment and assessed buoy performance using simulation.
- Completed design for packaged configuration and deployment sequence.
- Developed energy harvesting technologies and conducted engineering tests.
- Demonstrated feasibility of using nanofluidic technology with moving magnets in a linear generator to harvest wave energy.
- Characterized ferrofluidic material and developed electromagnetic models.

FY 2008 Plans:

- Integrate energy harvesting technologies with station keeping technologies and conduct demonstration/test at sea.
- Perform trade-off analysis to determine buoy sensor payload for persistent ocean surveillance demonstration in fleet exercise.
- Conduct at-sea testing to demonstrate persistence and survivability.
- Identify payload package of high utility to the Navy and commence integration into the station keeping buoy.

FY 2009 Plans:

- Conduct demonstration of persistent ocean surveillance with a sensor payload package of high utility to the Navy.

	FY 2007	FY 2008	FY 2009
Aluminum Combuster*	2.392	1.359	2.500

*Previously funded under Mobile Undersea Distributed Systems (MUDS).

(U) The Aluminum Combustor program seeks to develop an energy-dense air-independent underwater power source as a propulsion system for future naval undersea warfare systems. This program will optimize the design for a small aluminum combustor, silane fuel treatment process, and develop the auxiliary power system components needed to control and sustain operations. In addition to the combustor, the aluminum fuel feed subsystem, aluminum-steam separator subsystem; and closed loop control subsystem will be designed, built, and integrated with a turbine in order to successfully demonstrate a power system in a laboratory environment. Upon successful completion of the laboratory tests, DARPA will investigate novel naval applications for an energy dense air independent propulsion system. The power system will then be integrated into a Navy submersible and tested at sea. The Aluminum Combustor technology is anticipated to transition to the Navy in FY 2011.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-02

(U) Program Plans:

FY 2007 Accomplishments:

- Designed and fabricated the low Hp combustor, aluminum fuel feed subsystem, aluminum-steam separator subsystem; and closed loop control subsystem.
- Commenced integration of the power system in the laboratory.
- Designed a long endurance aluminum fuel feed subsystem.

FY 2008 Plans:

- Develop and optimize silane fuel treatment protocol to improve operating characteristics of the aluminum combustor.
- Investigate novel naval applications.

FY 2009 Plans:

- Modify or redesign the components from the laboratory Aluminum Combustor Power System for use in a UUV.
- Integrate and test the components as a system in the laboratory.

	FY 2007	FY 2008	FY 2009
River Eye*	4.557	2.950	2.000

*Previously funded under Mobile Undersea Distributed Systems (MUDS).

(U) Early entry maritime forces need maps of morphology, water depths, and currents in complex riverine/estuarine environments for mission planning and execution. This information is critical for route planning, sensor placement, rendezvous determination, vulnerability assessments, and determining objective assault engagement/disengagement strategies. For uncharted and/or denied areas, present methods are inadequate for obtaining the necessary information. Reliable remote sensing methods do not exist that produce bathymetry and water current data in waters that are sediment laden (bottom is not visible) and/or sheltered (swell and significant wind waves are not likely). The River Eye effort will provide a new capability to predict or assess, in real time, river and estuary conditions to enable special operations mission planning and execution. New techniques will be developed to indirectly determine current speed and direction by remotely sensing advection of scene features. Using advanced modeling techniques, indirectly sensed current data will be used to extract bathymetry data. Forward circulation models will use the bathymetry data to predict future currents and water heights in a mission planning decision support tool. The River Eye effort is anticipated to transition to the Navy and National Geospatial-Intelligence Agency in FY 2010.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-02

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted airborne and satellite data collections in well-mixed, instrumented estuary.
- Developed image-processing algorithms for extracting circulation currents.

FY 2008 Plans:

- Develop a simulation/model inputting simple idealized bathymetries to generate a circulation field and an inverse model that used the circulation field as an input parameter and calculated the bathymetry.
- Conduct instrumented data collections in a new environment and evaluate performance.
- Conduct additional instrumented data collections to evaluate the performance of an initial inverse model.

FY 2009 Plans:

- Continue development of the inverse model for extracting bathymetry from indirectly sensed currents.
- Refine and tune algorithms for extracting circulation currents and bathymetry in more complex environments.

	FY 2007	FY 2008	FY 2009
Jet Blast Deflector (JBD)	1.000	0.000	0.000

(U) The Jet Blast Deflector (JBD) program used multifunctional materials developed under the DARPA Structural Material Program (PE 0602715E) to construct a passively cooled jet blast deflection that increased reliability and met weight reduction requirements for current and future classes of aircraft carriers.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated operation under damaged conditions.
- Proved that the passively cooled JBD could exploit the flow from the aircraft engines to induce sufficient ambient air-flow to remove all heat and to return the JBD to the Navy-specified maximum temperature.
- Proved that structurally the passive JBD could withstand the loads from an aircraft landing on a single wheel with a flat tire (worst case scenario).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-02

	FY 2007	FY 2008	FY 2009
Tango Bravo	12.000	17.934	20.721

(U) Based on the results of the DARPA/Navy Submarine Design Study, the Tango Bravo technology demonstration program is exploring design options for a reduced-size submarine with equivalent capability of the VIRGINIA Class submarine. The implicit goal of this program is to reduce platform infrastructure and, ultimately, the cost of future design and production of submarines. The program is a collaborative effort to overcome selected technological barriers that are judged to have a significant impact on submarine platform and infrastructure cost. DARPA and the Navy, under a Memorandum of Agreement, jointly formulated technical objectives for critical technology demonstrations in: (1) shaftless propulsion, (2) external weapons stowage and launch, (3) conformal alternatives to the existing spherical sonar array, (4) radical ship infrastructure reduction technologies that eliminate or substantially simplify hull, mechanical and electrical systems, and (5) automated attack center technologies to reduce crew manning.

(U) Following success of shaftless propulsion technologies demonstrated in the Tango Bravo program, DARPA and the U.S. Navy will design, build, and test a large scale Submarine Shaftless Stern Demonstrator to characterize and mitigate risks associated with ship integration into a next generation submarine propulsion option. The Demonstrator will be built to the minimum scale necessary to extrapolate hydrodynamics, powering, and acoustics to full-scale performance. The most cost effective technical approach to developing the demonstrator design will be considered, including the modification of existing large-scale submarines.

(U) Elements of the Tango Bravo program will begin transition to the Navy in FY 2009, with full transition anticipated at the conclusion of the Submarine Shaftless Stern Demonstration in FY 2013.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed detail design review and final design review of the medium-scale Integrated Motor Propulsor and Drive (IMPaD) shaftless propulsion concept.
- Completed 1/12 full scale (model scale) hydrodynamic and hydro-acoustic testing of the shaftless propulsion propulsor in the forty-eight inch water tunnel.
- Completed the shaftless propulsion motor drive breadboard testing and initiated fabrication of the medium scale drive and controller.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-02

- Completed design, fabrication, and land-based testing of the External Weapons Stowage and Launch full-scale system.
- Completed the Radical Ship Infrastructure Reduction project (Electric Actuation of Stern Planes and Rudder), including satisfactory demonstration of criteria (static load performance, range of motion, rate of motion, and bearing shock tests).
- Completed fabrication of the full-scale electric actuator and controller/drive in preparation for actuator dynamic testing.

FY 2008 Plans:

- Complete shaftless propulsion component fabrication (motor propulsor, duct, and structure.).
- Complete the propulsion plant cost model to demonstrate the Shaftless Propulsion concept reduces submarine construction costs.
- Evaluate Shaftless Propulsion criteria for continuation with the program, an eighteen-month effort that includes demonstrator assembly and integration followed by thorough in-water system testing.
- Conduct concept studies for the Submarine Shaftless Stern Demonstration.
- Assess programmatic and technical trade-offs to determine the optimum platform for the Submarine Shaftless Stern Demonstration.
- Complete the External Weapons Stowage and Launch project by conducting full-scale, test depth, weapons launch testing.
- Conduct weapon load/reload demonstration.
- Complete the Radical Ship Infrastructure Reduction project by conducting testing of the electric actuator, including approximately one million full cycles of the actuator under representative at-sea dynamic loadings and pressures.

FY 2009 Plans:

- Complete Shaftless Propulsion integrated system testing.
- Perform design studies and computational analysis to establish critical design parameters for the Submarine Shaftless Stern Demonstration.

	FY 2007	FY 2008	FY 2009
Sea Shield	0.000	0.000	3.000

(U) The Sea Shield program will develop an extensible automated battle management (ABM) capability to provide persistent surveillance and targeting coverage to protect naval battle groups against overwhelming threats. Sea Shield will extend area protection 50-fold using layered and distributed sensing and targeting, through developing and implementing air, sea and subsurface autonomous, collaborative and self-healing sensor networks. The ABM system will enable timely and coordinated decision-making information and situational awareness for the commander. Sea

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E, Project NET-02

Shield will enable intelligent deployment of shield sensors and network infrastructures, to protect Sea-Base assets, through effective cross-platform and multi-mission resource management, and distributed weapons coordination for increased raid size and heterogeneous threat types. Sea Shield will also enable the Sea-Base to decouple intelligence, surveillance, and reconnaissance/defense missions from offensive missions improving the power projection capability of the deployed force.

(U) Program Plans:
FY 2009 Plans:
- Develop ABM technologies for detection, classification, localization, tracking and optimized engagement of sea-skimming cruise missiles.
- Develop ABM for antisubmarine warfare.
- Assess effectiveness of ABM component technologies through modeling and simulation.
- Begin integration of mature components for subsystem test and evaluation.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Sensor Technology; PE 0603767E

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	189.795	195.213	226.470	224.477	233.798	247.071	249.050
Surveillance and Countermeasures Technology SEN-01	45.562	63.497	80.723	80.774	83.760	97.034	99.014
Sensors & Exploitation Systems SEN-02	144.233	131.716	145.747	143.703	150.038	150.037	150.036

(U) Mission Description:

(U) The Sensors Technology program element is budgeted in the Advanced Technology Development Budget Activity because it funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment.

(U) The Surveillance and Countermeasures Technology project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing and low-cost microelectronics to develop advanced surveillance and targeting systems. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with tactical information needed to succeed in future wars. Additionally, this project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats.

(U) The Sensors and Exploitation Systems project develops and demonstrates advanced sensors, and exploitation technologies. These efforts provide warfighters with situational awareness and precision target identification. The project is driven by four needs: 1) countering camouflage, concealment and deception (CC&D) of mobile ground targets; 2) providing near-real-time, semi-automatic exploitation of wide-area moderate and high-resolution imagery; 3) obtaining real-time, accurate battle damage assessment; and 4) accomplishing robust, precise identification, precision fire control tracking and engagement of high value targets.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Sensor Technology; PE 0603767E

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	188.781	196.462	219.407
Current Budget	189.795	195.213	226.470
Total Adjustments	1.014	-1.249	7.063
Congressional program reductions	0.000	-1.249	
Congressional increases	0.000		
Reprogrammings	6.000		
SBIR/STTR transfer	-4.986		

(U) Change Summary Explanation:

FY 2007	Increase reflects an anticipated reprogramming and the SBIR/STTR transfer.
FY 2008	Decrease reflects reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.
FY 2009	Increase reflects expansion of SALTI program in Project SEN-02 and enhanced technologies to detect and defeat underground facilities in Project SEN-01.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Surveillance and Countermeasures Technology SEN-01	45.562	63.497	80.723	80.774	83.760	97.034	99.014

(U) Mission Description:

(U) This project funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability, and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing, and low-cost microelectronics to develop advanced surveillance and targeting systems. In addition, this project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. The collection of programs formerly referred to as Counter Underground Facilities has been expanded into separate programs (the Low-Altitude Airborne Sensor System (LAASS) program, the Cross-Border Tunnels (CBT) program, the Robust Tunnel Mapping and Operations program, and the Airborne Tomography using Active Electromagnetics (ATAEM) program) to provide additional insight.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Low-Altitude Airborne Sensor System (LAASS)*	10.472	19.464	15.750

*Previously part of Counter Underground Facilities (UGF).

(U) The Low-Altitude Airborne Sensor System (LAASS) program is developing an airborne sensor system to find and characterize underground facilities (UGFs) used to shield and protect strategic and tactical activities, including command and control, weapons storage, and manufacture of weapons of mass destruction (WMD). By passively capturing emissions associated with underground facility presence and operations, and doing so using airborne sensors (acoustic, electromagnetic, gravity), LAASS can significantly increase our ability to seek out

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

underground facilities and map out their vulnerabilities and backbone structure. LAASS technologies are planned to transition to NORTHCOM, SOUTHCOM, STRATCOM, or Defense Threat Reduction Agency (DTRA) at the end of FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed algorithm concepts and generated performance predictions for LAASS against Targets of Interest (TOI).
- Designed and developed prototype LAASS passive electromagnetic and acoustic sensor payload and tested sensor performance characteristics on an unmanned air vehicle (UAV).
- Identified and tested methods to isolate magnetometer sensor from platform vibration and electromagnetic interference.

FY 2008 Plans:

- Generate system design for passive demonstration and evaluation prototype system.
- Integrate and test passive sensor hardware (platform-isolated electromagnetic (EM), acoustic) onto user-specified unmanned air system (UAS).
- Develop system requirements for LAASS gravity gradiometer payloads (sensor characteristics, platform envelope) against TOI.

FY 2009 Plans:

- Develop and integrate passive system software (detection, characterization) and demonstrate system performance against a relevant facility.
- Produce system design and initiate development of gravity gradiometer prototype evaluation system.

	FY 2007	FY 2008	FY 2009
Cross-Border Tunnel (CBT)*	0.676	1.852	3.750

*Previously under Counter Underground Facilities (UGF).

(U) The Cross-Border Tunnel (CBT) program is developing technologies and systems to detect small tunnels used to breach security perimeters and national borders. The program goal is to develop innovative technologies inspired by geophysical exploration techniques that detect and characterize these threat tunnels while simultaneously satisfying operational considerations such as search rate, site access, and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

exposure of friendly forces. The CBT program is currently performing collections of seismic and electromagnetic (EM) data at a test bed using current state of the art sensors from the geophysical industry.

(U) Starting in FY 2008, the program will focus on a Fast-Scan CBT Detection technique, which will investigate, develop, and transition a tunnel detection system focused on providing a fast linear scan rate, for operationally tractable protection of large controlled areas or national borders. Current subterranean interrogation techniques based on geophysical exploration methods have the combined impediments of slow interrogation rate, need for complete site access, or exposure of forces. Contrary to invasive imaging methods, the Fast-Scan concept is to provide rapid detection of anomalous subsurface structures consistent with voids. The technical challenges include: 1) identification of optimal detection strategies, source characteristics, and sensor geometries, 2) rejection of clutter with length scales similar to tunnels or response from non-threat structures (utilities), and 3) technology migration to a moving platform. This program will transition to the Services in FY 2010.

(U) Program Plans:

FY 2007 Accomplishments:

- Built test bed for evaluation of CBT and other Counter Underground Facilities (CUGF) technologies.
- Tested innovative imaging techniques using seismic and electromagnetic illumination of Target of Interest (TOI.)
- Assessed methods for robust employment subject to operational limitations.

FY 2008 Plans:

- Investigate alternative technologies contributing to the Fast Scan CBT Detection technique.

FY 2009 Plans:

- Develop and validate a detection concept suited for use in protection of controlled areas and borders.
- Determine the design requirements for the source characteristics and sensor/source geometry that optimizes the detection performance.
- Commence the development of the Fast Scan CBT Detection technique for an off board platform integration.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

	FY 2007	FY 2008	FY 2009
Robust Tunnel Mapping and Operations	0.000	0.000	3.970

*Previously under Counter Underground Facilities (UGF).

(U) The Robust Tunnel Mapping and Operations program will investigate, develop, and transition a single system that jointly maps underground tunnel networks and supports below-ground communications and navigation, to meet the operational needs of ground forces conducting urban or counter-UGF operations. The program will explore and identify active sensing strategies that in the process of mapping the extent of the tunnel network can simultaneously support internal operations. The technical challenges include 1) identification of a single phenomenology to meet mapping and operational needs, 2) development of man-portable sensors for communications and navigation, and 3) technology integration to a single system. This program will transition to Special Operations Forces in FY 2011.

(U) Program Plans:

FY 2009 Plans:

- Develop and verify concept feasibility to meet the needs of ground forces conducting urban or counter-UGF operations.
- Quantify achievable system performance in an environment of underground tunnel networks.
- Establish design requirements for source characteristics (location, spectrum, duration) and sensor/radios.

	FY 2007	FY 2008	FY 2009
Airborne Tomography using Active Electromagnetics (ATAEM)	4.196	5.409	9.136

(U) The Airborne Tomography using Active Electromagnetics (ATAEM) program is developing an active electromagnetic (EM) system for airborne imaging of subsurface structures, such as underground facilities (UGF) or perimeter-breaching tunnels. The ATAEM system illuminates the ground with electromagnetic energy and interprets resulting distortions of the electric and magnetic fields to detect and characterize surreptitious structures. The ATAEM program will investigate and develop the component technologies, including EM illumination sources, noise-isolated sensor payloads and signal processing, and demonstrate them on an appropriate airborne platform. The ATAEM program will first validate the system concept for EM sources, sensor payloads, and associated signal processing through modeling and data collection against

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

relevant underground structures. An integrated system combining active illumination, sensing, and detection processing will then be developed and demonstrated on an appropriate unattended air system (UAS). This capability is expected to transition to the Army, USMC, and U.S. Special Operations Command in FY 2011.

(U) Program Plans:

FY 2007 Accomplishments:

– Developed sensor suite comprised of vibration-isolated electric and magnetic field sensors.

FY 2008 Plans:

– Build sensor suite comprised of vibration-isolated electric and magnetic field sensors.
– Investigate and develop electromagnetic illumination sources.
– Integrate sensor suite into helicopter tow body.

FY 2009 Plans:

– Collect and analyze operationally relevant data over multiple Targets of Interest (TOI) using helicopter tow body.
– Document performance as a function of operational parameters (illumination sources, flight parameters).
– Develop system design for final demonstration system.

	FY 2007	FY 2008	FY 2009
Strategically Hardened Facility Defeat	4.000	12.000	15.500

(U) Building upon the successes of this technology developed under the Counter Underground Facilities program, the Strategically Hardened Facility Defeat program will continue to develop alternative earth-penetrating technologies for the defeat of strategically hardened targets. The threat posed by the proliferation of hard and deeply buried targets with major strategic capabilities around the world is increasing dramatically. These strategically hardened facilities are used to harbor our adversaries' most dangerous assets including leadership bunkers, command and control functions, and weapons of mass destruction. However, because the size and weight of traditional earth penetrating weapons scale exponentially with the depth of the facility, current warhead penetration depths are and always will be insufficient to reach many of these targets. As a result, a strategic capability gap exists and new approaches to earth penetration and warhead delivery are needed. This program seeks to

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

leverage recent advances in earth-penetrating technologies for full defeat of strategically hardened facilities. This program will transition to the Defense Threat Reduction Agency (DTRA) in FY 2011.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed new penetration technologies capable of meeting deployable weight and size goals.
- Demonstrated advanced penetration and energy supply technologies through field trials.
- Developed the ability to sense and navigate to the targeted functional area.
- Demonstrated sensing and navigation capabilities through field data collections and high fidelity modeling.
- Conducted small-scale tests of deployment capabilities.

FY 2008 Plans:

- Develop robust, self-contained aerial deployment options that can interface with existing air platforms.
- Integrate advanced penetration and energy supply technologies.
- Demonstrate penetration, energy, sensing, and navigation capabilities through field trials.
- Demonstrate deployment capabilities.

FY 2009 Plans:

- Develop packaging and integration technologies that can withstand harsh environments.
- Design and initiate development of deployable system with advanced penetration and navigation capabilities.
- Integrate component subsystems into deployable platform.

	FY 2007	FY 2008	FY 2009
Visibuilding	11.218	9.000	10.000

(U) The Visibuilding program is developing technologies and systems for new surveillance capabilities of buildings, to detect personnel within buildings, to determine building layouts, and to locate weapons caches and shielded enclosures within buildings. Radar signals are being used to image static structures directly. Doppler processing of radar signals is also being exploited to find, identify, and perform feature-aided tracking of moving personnel within a building and allow mapping of building pathways and stairways by monitoring traffic through buildings. Multipath

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

and propagation effects are modeled and iteratively compared with hypotheses of building structures to provide 3-D building maps and large concentrations of metal materials like weapons. This program is developing techniques to inject and recover probing waveforms and to unravel the complicated multipath in the return signals, to enable the mapping and characterization of buildings. Transition of component pieces to the Army's PEO Soldier and United States Special Operations Command will commence in FY 2009.

(U) The Radar Scope program is a quick-response effort to provide pre-production prototypes of hand-held through-wall personnel detection radar. It will be able to sense through common wall materials to detect potential enemies before warfighters enter a room or building. The final product is a small sensor with a simple interface that weighs less than two pounds including batteries. The unit detects individuals through typical non-metallic wall materials (e.g., concrete, concrete block, adobe, wallboard, plywood, etc.) up to twelve inches thick. Transition to the Army Rapid Equipping Force via PEO Soldier Sensor and Lasers is anticipated. Follow-up technologies have been requested for sniper self defense, tunnel inspection, perimeter defense, remote operations, and finding objects buried in walls.

(U) Program Plans:

– Visibuilding

FY 2007 Accomplishments:

-- Evaluated candidate designs for wall-penetrating technologies for building layout and combatant localization.
-- Performed electromagnetic simulations showing detailed building penetration physics.
-- Developed algorithms for determining building layouts from electromagnetic radar returns.

FY 2008 Plans:

-- Develop instrumentation radar systems for detailed building radar measurements.
-- Perform experiments on building imaging and insurgent localization within structures.

FY 2009 Plans:

-- Demonstrate multipath exploitation approaches for interior building imagery through three exterior-grade walls.
-- Design, build, and test prototypes for use in full-scale demonstration.

– Radar Scope

FY 2007 Accomplishments:

-- Evaluated candidate designs for through wall motion detection.
-- Carried out feasibility measurements and modeling.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

-- Designed, built and tested prototypes for use in full-scale demonstration.
-- Transitioned for use in full-scale demonstration.

FY 2008 Plans:

-- Develop extensions of this technology for new application areas, including standoff triage tools for use by medics.

	FY 2007	FY 2008	FY 2009
Surveillance and Threat Neutralization in Urban Environments	7.000	5.772	0.000

(U) This program is investigating technologies to demonstrate the detection and defeat of threats specific to conflict and stabilization operations in the urban environment. These threats include roadside bombs, car bombs, suicide bombers, snipers, rocket propelled grenades, and mortars launched from inside urban boundaries. Detection technologies studied included detection of anomalies in vehicle dynamics; stand-off identification and localization of explosive vapors/effluents; high fidelity 3-Dimensional (3-D) mapping performed from a high altitude (>15,000 feet) airborne platform for Improvised Explosive Device (IED) detection, high fidelity 3-D surveillance performed from autogyro mortar rounds utilizing stereo vision, and precision emplacement of sensors in an urban environment. These capabilities will be transitioned to Army and Special Operations ground forces to support urban operations planning with an initial focus on the targeting and intelligence components in FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

– Completed study on Detection of Anomalies in Vehicle Dynamics (DAViD) and documented results.
– Completed successful airborne demonstration of data-driven high resolution 3-D Laser Identification Detection and Ranging (LIDAR).
– Completed initial sensor development to enable non line of sight (NLOS) sensors.

FY 2008 Plans:

– Evaluate candidate technologies for wide-area/stand-off and choke-point/portal-screening applications.
– Prove feasibility in lab on sub-scale tests.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

	FY 2007	FY 2008	FY 2009
Hostile Fire Indicator (HFI)	2.000	0.000	0.000

(U) The Hostile Fire Indicator (HFI) program explored an airborne extension of the Boomerang Rapid Response program to provide rotorcraft with situational awareness of small arms fire. Currently, pilots may be unaware that they are receiving small arms fire until it impacts near the crew cabin or some other critical and monitored system. The HFI system was designed to detect and locate the source of any small arms projectiles passing within meters of aircraft with a high probability of detection and precise source-location accuracy.

(U) Program Plans:

FY 2007 Accomplishments:

– Measured acoustic/vibrational frequency background noise on one U.S. Army and two Special Operation Forces helicopters.

	FY 2007	FY 2008	FY 2009
Speckle Exploitation for Enhanced Reconnaissance (SEER)	4.000	7.000	6.000

(U) The Speckle Exploitation for Enhanced Reconnaissance (SEER) program will provide long-range non-cooperative identification of moving/stationary targets using incoherent scattered laser speckle reflected off a target surface. Laser speckle has reduced sensitivity to adverse turbulence-induced distortion and so should provide a viable signal at ranges exceeding those projected for other active laser systems. Technical achievements under other programs in this PE/Project provide the basis for radically new approaches to measuring target characteristics under conditions that limit the performance of conventional sensors. Target characteristics potentially obtainable may include target image, shape, size, structural features, and other advanced threat properties. By extending the operating range of current active electro-optic sensors, SEER enables the friendly platform to stand off from the maximum operating range of hostile sensors/weapons, while executing the targeting task and directing weapons against targets. Transition to the Army is expected to occur by FY 2012.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

(U) Program Plans:

FY 2007 Accomplishments:

– Conducted system concept developments and laboratory proof-of-concept demonstrations.

FY 2008 Plans:

– Develop algorithms that reliably and uniquely associate target signatures with speckle patterns.
– Implement algorithms using optical Micro Electro-Mechanical systems (MEMs) or other related technologies to achieve reduced size, weight and power.
– Demonstrate functional performance of single focal plane array to create active speckle images of calibration and field targets.

FY 2009 Plans:

– Perform major system design trades.
– Demonstrate multiple focal plane array foliage penetration performance (spatial resolution and composite image formation time).
– Conduct field experiments to measure brassboard performance in turbulent environments.

	FY 2007	FY 2008	FY 2009
Rescue Transponder (RT)	2.000	3.000	2.000

(U) Building upon technologies developed in other sensor programs, the Rescue Transponder (RT) program will investigate the use of a unique localization and tracking technology to provide a very low probability of detection (LPD) call for help signal. The system will use a wide band radio frequency signal with low power and extremely low duty cycle. The goals of the RT Program are to develop a small, rugged, transponder that provides a call for help to friendly forces. The RT system will operate over ranges that enable rescue forces or surveillance systems to receive its signals. It will support accurate localization by rescue forces, and permit transmission of identifying, authenticating, and status information. The RT technology is planned for transition to the Army and USMC in 2009.

(U) Program Plans:

FY 2007 Accomplishments:

– Developed tags that enabled the user to be identified and localized by airborne or advantaged receivers.
– Designed a custom digital and microwave-integrated circuit to allow tag miniaturization.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

– Built, tested, and demonstrated the prototype tags and transmitters capabilities at military facilities.
– Conducted airborne demonstration and completed interference and low probability of detection (LPD) assessment to demonstrate military utility to transition partner USMC at Camp Pendleton, CA and Quantico, VA.

FY 2008 Plans:
– Initiate limited prototype production to support USMC operational field assessment.
– Complete equipment development and enhancements to support system performance capabilities for military use.

FY 2009 Plans:
– Complete transition between DARPA and USMC.

	FY 2007	FY 2008	FY 2009
AudiVis	0.000	0.000	3.500

(U) The AudiVis program seeks to extract high-rate (kHz+) temporal data from a foveated vision infrared (IR) sensor. This provides the capability to optimize data processing at the pixel level, including data fusion in real time at the pixel level. The concept goes well beyond foveated vision and bandwidth sensor compression concepts by enabling a low light sensor to not only act as an intelligent cueing device but also to shift to a high frame rate mode. This will provide visible IR with applications into complimentary metal-oxide-semiconductor visible sensors as well as temporal (frequency) data on objects of interest within the field of view of the IR sensor. This will enable the detection of acoustic and high modulation rate signatures from low-light IR sensor and provide on-sensor data fusion capabilities for rapid detection and identification. The use of a networked array of these high frequency capable low light sensors in an urban environment will provide autonomous situational awareness. This program will transition to the Army for urban operations applications in FY 2012.

(U) Program Plans:

FY 2009 Plans:
– Define system performance requirements.
– Develop system architecture design.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

	FY 2007	FY 2008	FY 2009
Combat Laser Infrared Countermeasure (IRCM) Proactive Survivability System	0.000	0.000	3.000

(U) The Combat Laser Infrared Countermeasure (IRCM) Proactive Survivability System (CLIPSS) will enable air dominance at low altitude and at night against current and near term near infrared (NIR) and mid-wave infrared (MWIR) based threats including man portable air defense (MANPAD), based on proactive infrared countermeasures (PIRCM). Leveraging the ongoing systems and focal plane array (FPA) technology development established by the Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program (budgeted in PE 0603768E, Project GT-01) in the near and MWIR bands and the reactive capability of the Affordable Laser IRCM Survivability System (ALISS), CLIPSS will provide a near term demonstration and transition of the proactive capability and serve as a pathfinder for the longer range, all band objectives of MEDUSA. CLIPSS will provide U.S. aircraft the same ability to geo-locate, evade, jam, or destroy optically based air defenses and will evolve U.S. capabilities from reactive end game countermeasures to proactive capabilities that increase threat-warning times, deny launch and put electro-optical/IR air defense threats at risk. This program will demonstrate an initial integrated proactive and reactive IRCM pod based flight system that will address shorter range, high duty cycle threats for vulnerable low altitude platforms in the NMIR wavebands. The primary technical obstacles will be the continued development and integration of high sensitivity infrared Focal Plane Array (FPA) and multi-frequency laser technologies into compact, efficient packages for demanding IRCM environments. The real-time processing of the range resolved laser returns over wide fields of view to rapidly cue the proactive countermeasures poses a significant systems integration challenge as well. CLIPSS technology is planned for transition to the Services in FY 2012.

(U) Program Plans:

FY 2009 Plans:

- Develop preliminary design for integrated proactive IRCM pod incorporating current reactive IRCM capabilities and components.
- Demonstrate integrated subsystem performance for transmitters and receivers.
- Develop final design incorporating advanced high gain 128x128 FPAs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

	FY 2007	FY 2008	FY 2009
Handheld Through-Wall Synthetic Aperture Radar (SAR)	0.000	0.000	2.500

(U) Urban operations have become an essential part of military and peace-keeping operations. Currently, buildings provide a safe refuge from our reconnaissance and surveillance capabilities. Technology developed in the Radar Scope program provides a personnel detection device which can detect movement of people through non-metallic walls like concrete, adobe, cinderblock, or drywall. Some commercial techniques attempt to provide crude imaging of a room's contents, but are limited by the size and aperture of the device. This program will provide an synthetic aperture imaging capability into a room by sweeping a small handheld system over the face of a wall, an arbitrarily large aperture can be recreated to improve the imaging capability to the physical propagation and dispersion limits of the wall. This program will transition to the Army in FY 2011.

(U) Program Plans:
FY 2009 Plans:
- Perform through-wall measurements to measure propagation and dispersion effects.
- Develop motion measurement capabilities for monitoring the position of the radar for synthetic aperture measurement.
- Develop imaging algorithms that compensate for wall penetration effects.

	FY 2007	FY 2008	FY 2009
Standoff Triage	0.000	0.000	3.000

(U) Medics who risk their lives under fire to assess individuals who may already be dead incur many casualties. Current technologies have demonstrated breathing or heart rate detection using radar systems, as well as other life signs such as pulse using laser vibrometry or infrared and even chemical detection of respiration products. These measurements have usually been under well-controlled environments. The Standoff Triage program will extend these approaches to allow remote monitoring of life in battlefield environments to determine the state of individuals before sending in emergency medical personnel under fire. This effort will examine optical, infrared, and RF techniques to monitor key life signs such as respiration and heart rate to determine the timing and magnitude of a potential medical response. The Standoff Triage program will develop methods to measure health status of people at distances of 10 to 100 meters, and will be evaluated for both handheld operations by medics

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-01

on the ground and airborne platforms that can survey a battlefield after a conflict. In addition to casualty assessment, these technologies may be useful in disaster relief or detecting the presence of potential adversaries. This program will transition to the Army and USMC in 2012.

(U) Program Plans:
FY 2009 Plans:
- Evaluate candidate designs for remotely monitoring human life signs in battlefield scenarios.
- Carry out feasibility measurements and modeling.
- Design, build, and test prototypes for use in full-scale demonstration.

	FY 2007	FY 2008	FY 2009
Dielectric Detection of Explosives	0.000	0.000	2.617

(U) The Dielectric Detection of Explosives program will develop a system for the detection of bombs that have become deadly and destructive weapons in current urban operations. The approach will measure dielectric properties of materials to discriminate classes of materials. Low frequency dielectric spectral signatures can be obtained through clothes, walls, and other non-metallic surfaces. Based upon the size of the sensor system, these signatures can potentially be pushed out to several meters. This can enable portal defense application, vehicle inspection, and even monitoring of explosive materials through walls. The Dielectric Detection of Explosives approach can be integrated with signatures from other sensors to provide a more comprehensive multi-spectral discrimination solution. Transition is planned to the Army and Marine Corps in FY 2012.

(U) Program Plans:
FY 2009 Plans:
- Develop collection sub system for demonstrating feasibility of material discrimination and object classification.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Sensors & Exploitation Systems SEN-02	144.233	131.716	145.747	143.703	150.038	150.037	150.036

(U) Mission Description:

(U) The Sensors and Exploitation Systems project develops and demonstrates advanced sensor and exploitation technologies to provide accurate situational awareness and precise target identification. The project is driven by five needs: (a) integrating data from multiple sources into consistent situation assessments; (b) countering camouflage, concealment and deception of mobile ground targets; (c) providing near-real-time semi-automatic exploitation of wide-area moderate- and high-resolution imagery; (d) obtaining real-time, accurate battle damage assessment; and (e) accomplishing robust, precise identification, precision fire control tracking and engagement of ground targets. These needs are addressed in eight thrusts: 1) Persistent Exploitation, to combine sensors and exploitation tools in an integrated system to address counter-insurgency missions; 2) Network Centric Sensing and Engagement, to explore novel processing architectures enabled by the proliferation of data links; 3) Pattern Analysis Technology, to distinguish suspicious movement and activity from benign clutter; 4) Target Identification Technology, to build tools to automatically identify targets; 5) Advanced Radar Sensing Technology, to observe targets at night and in bad weather; 6) Advanced Airborne Optical Sensing, to provide high-resolution images over large areas; 7) Synthetic Aperture Ladar for Tactical Imaging (SALTI), to produce high-resolution 3-D imagery at long ranges; 8) Ground Targeting Sensors, to increase our ability to detect close-in ground targets; and 9) Soldier-borne Sensor Technology, to improve individual soldiers' situational awareness and effectiveness.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Persistent Exploitation	20.262	20.632	23.178

(U) The Persistent Exploitation program integrates a wide variety of sensors, data links, exploitation tools, correlators, and pattern analyzers into an end-to-end capability, focusing on counter-insurgency missions. These missions must be supported at all hours of the day, over large areas, and against a diverse set of targets, characteristics that no homogeneous sensor architecture can address. It ties separate hardware and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

software components together so that interactions among them can be defined, assessed, evaluated, and refined. It emphasizes real-time testing in realistic environments (e.g., the National Training Centers) so that subtle dependencies and interactions can be discovered.

(U) The Persistent Operational Surface Surveillance and Engagement (POSSE) program creates a system of systems framework in which a mix of surveillance assets, both operational and developmental, can be coordinated and exploited to yield persistent surveillance of insurgent activities. The program focus is on the Iraqi theatre, using a spiral approach designed to insert enhanced counter-insurgency capabilities into operational use as soon as possible, followed by improvements and enhancements as they become integrated through a domestic testbed. The efficacy and timeliness of surveillance afforded by the program's systems-level approach will significantly exceed that afforded by individual Intelligence, Surveillance, Reconnaissance (ISR) components, and will result in substantially enhanced force protection for fixed sites, convoys, and military operations. The framework includes data exploitation at both forward-deployed and national sites to support both quick-reaction cueing to engage insurgents, and deeper forensic analysis to identify their support structures. POSSE attacks the insurgent network to find activities indicative of bomb making perpetrators. The POSSE program is jointly funded with the Joint Improvised Explosive Device Defeat Task Force. POSSE technologies are planned for transition to the U.S. Army Intelligence and Security Command.

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted a comprehensive analysis of existing surveillance assets in the Iraqi theatre.
- Developed a systems architecture and asset utilization plan that maximizes persistent surveillance capability in high priority regions, based on currently available assets.
- Identified coverage and gaps and required new capability needed to satisfy persistent surveillance and force protection objectives.
- Defined a spiral development plan that emplaces initial capability in theatre as early as possible, and identifies needed enhancements and new capabilities to be inserted in subsequent phases.
- Exercised these systems in near-real time through a series of live exercises at the National Training Center (NTC), in a realistic operational environment, in direct support of units conducting Mission Readiness Exercises prior to deployment to Iraq.

FY 2008 Plans:

- Continue semi-annual exercises at the NTC, demonstrating continued maturation of the near-real-time exploitation capabilities.
- Integrate capabilities into existent operational ISR exploitation cells, evaluating them in NTC exercises and followed with transition to deployed analysis cells.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

- Expand investigation of close proximity sensor experiments designed to differentiate a bomb maker's location from adjacent structures.
- Integrate proximity sensor capabilities into the near-real-time POSSE exploitation process.
- Evolve the temporary test facilities at the NTC into a more permanent test facility, Joint IED Attack the Network Testbed (JIANT).
- Expand JIANT to be accessible to other DoD programs and provide connectivity to operational and R&D facilities.

FY 2009 Plans:

- Continue spiral development with semi-annual exercises at the NTC and spin off mature capabilities to deployed analysis cells.
- Exercise JIANT in coordination with remote operational and R&D facilities to test and demonstrate operational capabilities.
- Evolve JIANT accessibility and utility to programs beyond POSSE as a DoD test bed.
- Test operational capabilities at the NTC with operational analysis cells and deploy demonstrated capabilities to theater.

	FY 2007	FY 2008	FY 2009
Network Centric Sensing and Engagement	13.900	11.419	5.585

(U) The Network Centric Sensing and Engagement thrust develops technology and tools to support precise situational awareness, rapid targeting, and precision engagement in highly-networked environments. Network-centric sensing acknowledges a group of sensors as a system and leverages networked intercommunication to enable system performance superior to that of uncoordinated individual sensors. Applications include advanced target detection, acquisition, tracking, and combat identification. The technology is suited to both ground-based sensors and airborne multi-ship sensor systems. Exploiting the potential of network-centric sensing requires a number of approaches. Required technology advances include: sensor-to-sensor communications, multi-sensor management, sensor system georegistration, real-time data fusion, advanced tracking, and network-centric sensor operational modes. Programs in this thrust include:

- The Quint Networking Technology (QNT) is a modular, multi-band, network data link program focused on providing capabilities that close the seams between four nodes - manned aircraft, weapons, tactical unmanned air vehicles (UAV's) and air control ground units. The program designs, develops, evaluates and demonstrates robust, affordable data link technologies suitable for use by weapons, tactical UAV's, and air control units. This includes shrinking the package size of data link capabilities from the current 1000 in^3 to 10 in^3, the size of a cell phone. These data links enable precision strike and efficient machine-to-machine targeting against time critical and mobile

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

targets, support combat identification of targets, disseminate tactical UAV and ground sensor data, and provide bomb impact assessment (BIA). The data links allow secure weapon handoff from the launch platform to any of several control platforms in the combat area, both air and surface. The QNT units provide two modes: a low rate bi-directional mode and a high data rate mode capable of either continuous or a burst imagery/video transmission. Dynamic net resource management technology will scale to support hundreds of vehicles in flight. Advanced information security techniques provide secure weapon data links and controller handovers. QNT technology transitions via insertion into DoD's existing and emerging weapons, tactical UAV's, and tactical handheld units after the program is completed in FY 2009.

- The Wide Area Video Exploitation program will develop technology to enable wide field-of-view Electro-Optical/Infrared (EO/IR) imagery framing cameras in airborne platforms to detect and track, in real time, multiple moving objects under a wide range of conditions and topography. Current systems are able to collect data and provide an ability to backtrack individual targets post-facto. The Sonoma-Plus program aims to provide a real-time ability to track in forward time multiple potential targets from high-altitude video imagery. On-board processing will be crucial since imagery data volumes will amount to gigabytes per second. Multi-hypothesis tracking of dozens and eventually hundreds of entities will also be developed, and imagery stabilization based on prior digital elevation models will also facilitate tracking and track analysis. Technologies are planned for transition to the Army.

- The Expeditionary Distributed Common Group System (DCGS) Global Information Grid (GIG) for Exploitation Services (EDGES) program provides layered and persistent Intelligence, Surveillance and Reconnaissance (ISR) of asymmetric and irregular warfighters in support of Marine Corps and Special Operations. The unique feature of EDGES will be the ability to intelligently interpret soldier requests for situation assessment data, access local tactical threat data bases, and fuse multi-sensor data for accurate, timely target detection, tracking, and identification. This system approach couples the deployment of a dedicated UAV system responsive to these small units, with data preprocessing and feature extraction to enable the efficient and timely transmission of actionable combat information to the troops. With the ability to support two-way communications with wideband reach back, information and observations received from the small operation unit will be integrated into the EDGES information data base and communicated to the higher commands. Through the ISR processing algorithms, sensor fusion operations and communication connectivity to the area of regard as well as the higher level of commands, EDGES will function as an ISR tool to the small unit and provide actionable persistent and dedicated service. This program is planned to transition to the Marine Corps.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

(U) Program Plans:

– Quint Networking Technology (QNT)
FY 2007 Accomplishments:
-- Designed QNT radios, waveforms and network.
-- Conducted analysis, design and hardware-in-the-loop tests.
FY 2008 Plans:
-- Build and evaluate brassboard in Stage 1 tests.
FY 2009 Plans:
-- Cycle and test brassboard Stage 2 tests and flight tests.

– Wide Area Video Exploitation
FY 2007 Accomplishments:
-- Developed signal processing architecture.
-- Validated architecture on non-real-time data set.
FY 2008 Plans:
-- Prototype video processing architecture.

– Expeditionary DCGS GIG for Exploitation Services (EDGES)
FY 2009 Plans:
-- Develop and refine multi-sensor data fusion techniques to provide detection and classification of tactical threats.
-- Demonstrate high confidence identification of irregular warfighters through simulation, emulation, and field tests.
-- Develop a UAV “system” controlled by and responsive to the small unit with autonomous deployment and data collection capability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

	FY 2007	FY 2008	FY 2009
Pattern Analysis Technology	13.000	6.000	1.000

(U) The Pattern Analysis Technology thrust develops exploitation tools to form and analyze tracks of vehicle movement, and distinguish hostile behavior from benign civilian activities. It develops tools for movement pattern analysis, algorithms to predict target motions, and dynamic control methods for sensor tasking and observation scheduling. Programs in this thrust include:

- The Video Verification and Identification (VIVID) program develops technology to automate moving target strike operations for remotely piloted aircraft (RPA). Program products support both precision strike operations and military surveillance. VIVID enables the handoff of targets between wide area coverage Intelligence, Surveillance, and Reconnaissance systems and local video surveillance platforms. The technology provides techniques for precision target identification in video including fingerprinting techniques and related technology to reacquire previously observed vehicles. The program also features techniques enabling video sensors to autonomously and simultaneously track multiple vehicular targets through dense traffic, temporary occlusion or exit from sensor field of view, in military surveillance and strike operations, and supports target detection of moving vehicles and/or dismounts in very low resolutions. VIVID significantly advances the capabilities of video surveillance and moving target strike for numerous military missions, including military operations in foreign urban areas. DARPA has established a MOA with the Air Force to transition the VIVID technology to the Predator. The VIVID technology is planned for transition at the conclusion of Phase II which is anticipated to be completed by the end of FY 2008.

- The Dynamic Tactical Targeting (DTT) program develops sensor control and data fusion technologies to enable warfighters to manage a process to find, identify, track, target, and destroy mobile, time sensitive targets. Current targeting technology is too slow to maintain target track and support prosecution of these fleeting targets. DTT is designing and demonstrating a system that: 1) leverages existing National/Theater Intelligence, Surveillance, and Reconnaissance (ISR) processes for timely extraction of critical data; 2) fuses organic sensor data with ISR data from all sources to continuously estimate target location, identity, and activity; 3) dynamically tasks standoff, organic, and embedded sensors to fill ISR coverage gaps and provide relevant sensor observation in areas of tactical interest; and 4) processes and manages the voluminous data produced by various sensors in time to provide the warfighter information required to prosecute time-sensitive targets. The DTT technology is planned for transition to the Air Force in FY 2008 after a series of tests conducted with the Air Force Transformation Center.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

- The Forensic Target Motion Analysis program develops and demonstrates exploitation tools to analyze Ground Moving Target Indicator Radar tracks of multiple targets to separate militarily-interesting target movement (infiltrators, envelopments, defensive site preparation, logistics support) from nominal background traffic (e.g. civilians, coalition operations). It develops libraries of movement patterns, logic to generate hypotheses about which patterns are being observed, algorithms to correlate sensor data to those patterns, and mechanisms to quantitatively score the consistency of the data with each hypothesis. It also includes tools to provide short-term (5-10 minute) predictions of target motions, thereby supporting some forms of predictive threat analysis. The tools will be integrated into Distributed Common Ground Stations in FY 2009.

(U) Program Plans:

– Video Verification and Identification (VIVID)
FY 2007 Accomplishments:
-- Integrated real-time VIVID software with MTS Sensor.
FY 2008 Plans:
-- Demonstrate real-time software components on tower.

– Dynamic Tactical Targeting (DTT)
FY 2007 Accomplishments:
-- Demonstrated human interaction with closed-loop control of fusion and sensor management in a simulation environment.
-- Developed rapid 4-D registration of multiple tracks to enable continuous tracking of numerous targets.
-- Developed information fusion methods and the capability to plan and replan appropriate sensor platforms; enable continuous track of multiple time-sensitive targets simultaneously.
-- Developed end-to-end robust system capability with integrated DTT components in the Air Force Research Laboratory testbed.
-- Developed system measures of performance for evaluations.
FY 2008 Plans:
-- Integrate the system with an existing Air/Ground Battlespace Simulator/Testbed and perform experiments.
-- Complete a robust laboratory demonstration of the system.
-- Build system to test in field demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

– Forensic Target Motion Analysis
FY 2008 Plans:
-- Obtain ground-truthed, wide-area Ground Moving Target Indicator (GMTI) data from operational airborne sensors.
FY 2009 Plans:
-- Integrate into Distributed Common Ground Stations.

	FY 2007	FY 2008	FY 2009
Target Identification Technology	17.344	16.979	13.000

(U) The Target Identification Technology thrust develops semiautomatic methods to identify targets from sensors operating in all spectral bands. Its objective is to detect, characterize, and identify military threats, and to assess the environment around them. Data sources include national, theater, and organic sensors. Critical performance metrics are timeliness, accuracy, error rates, and interpretation workload. The thrust addresses the challenges of target identification, acquisition and tracking under restrictive rules of engagement. The technologies will apply advanced signal processing and machine vision to leverage advances in sensor capabilities. Four programs are funded in this thrust:

- The Tactical Sensor Network Technologies (TSNT) program developed detection, tracking, identification, and pattern analysis capabilities that operate in all nodes (fixed or mobile) within a networked, distributed multi-sensor system. The processing is performed at each network node depending on the sensors reporting to that node, the subscribing commanders, and resource management decisions. TSNT leveraged the advantages of a self-forming adaptive network for signal processing and its algorithms adapt based on self-discovered network topology, power management constraints, communications bandwidth limitations, and constraints found in the local environment. TSNT has demonstrated resilience to the failure of any node while maintaining sufficient consistency to support commanders' collaborative tactical planning. Technologies transitioned to the U.S. Army (PEO Intelligence and Electronic Warfare Directorate).

- The Exploitation of 3-D Data (E3D) program has developed techniques for rapidly exploiting 3-D sensor data. The initial program effort consisted of three distinct processes: Target Acquisition, Target Recognition, and Modeling. The resulting software tools were integrated into operational ground stations processing 3-D sensor data. The E3D technology was transitioned to SOCOM in FY 2006. The 3-D Reasoning (3DR) initiative is a follow-on program to E3D which will develop techniques to automatically generate large, fully annotated 3-D urban models from the rich sources of high-resolution laser radar data available from ground-based and airborne platforms. 3DR

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

extends vehicle-centric automated target recognition methods to support the much broader class of objects accessible in urban and complex terrain - particularly side-looking sensors mounted on patrol vehicles. The program consists of four distinct components: (1) new methods to rapidly and precisely co-register 3-D and 2-D data from disparate ground and airborne sources; (2) new 3-D recognition approaches that identify objects within a class based on limited initial training; (3) a flexible and expandable 3-D database structure to support the highly detailed and evolving urban models and provide the basis for geometry-based queries; and (4) a user interface that provides rapid and flexible access to the data. The resulting software tools and modeling capabilities will be integrated into future command posts and operational SOCOM and Army units in the field at the conclusion of the program, anticipated to be completed in FY 2008.

- The All-Source Target Characterization program develops a collection and measurement capability to characterize new targets as they emerge on the battlefield. This effort develops tools to permit rapid user interaction with imagery, sensor data, and processing results and provides real-time feedback to operators indicating key target features and other discriminates. The program will engage universities and industry to develop technology for integrated near real time automation support for real time airborne target acquisition and target confirmation using a combination of advanced radar exploitation and electro-optical/infrared imagery. This initiative will also develop and demonstrate robust target cueing and identification over large classes of targets within a computational form factor appropriate for insertion into strike aircraft and unmanned aerial vehicles. The technology provides tools to process and disseminate target signatures to the field in usable formats for direct insertion into operational systems. It enhances operator interfaces with extant analysis workstations to allow on-the-fly collection of signature data with little/no intervention for the operator. Technologies are planned for transition to the Air Force Distributed Common Ground Station in FY 2009 and subsequently to the U.S. Army Future Combat System. Most developmental work will be performed by universities and industrial contractors, with system architecture, performance trades, and evaluation performed by Government participants and transition partners.

- The Detect UAV program develops techniques to detect, track, and characterize small UAVs that are easily built, inexpensive, easy to operate, and offer the asymmetric adversary an ability to reach into well-defended locations causing potentially large amounts of damage. It includes signal processing techniques to detect small air targets in radar, video, acoustic, and passive radio-frequency intercepts; to correlate those data with known objects (e.g., civilian aircraft); to analyze the motion of any uncorrelated data; and to rapidly task narrow-field-of-view sensors to collect more-detailed data. It will transition to the Army in FY 2010 to meet both static force protection needs and tactical air defense operations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

(U) Program Plans:

– Tactical Sensor Network Technologies (TSNT)
FY 2007 Accomplishments:
-- Developed algorithms for distributed situation assessment at all nodes of a networked group of sensors.
-- Integrated and assessed distributed system performance in large-scale simulation and limited-scale testing.
-- Demonstrated robustness of TSNT networked sensing under network and environmental stresses.
-- Incorporated tracking, target identification, and target assignment algorithms for fully distributed operation.

– Exploitation of 3-D Data (E3D)
FY 2007 Accomplishments:
-- Demonstrated that the 3-D shape and structure of vehicles permits confident identification.
-- Conducted real data collection using laser radar, recognition by parts: 98% accuracy in <5 min.
-- Successfully demonstrated vehicle fingerprinting using shape and color.
FY 2008 Plans:
-- Conduct real time data collection with PFP of 90.3% in <10 secs for models in library.

– All-Source Target Characterization
FY 2007 Accomplishments:
-- Collected full spectrum data.
-- Analyzed reliability and sensitivity of each source.
FY 2008 Plans:
-- Develop tools to permit rapid user interaction with imagery and processing results.
FY 2009 Plans:
-- Evaluate performance in field exercises and demonstrations.

– Detect UAV
FY 2008 Plans:
-- Generate candidate system architecture, focusing on an effective sensor suite, to detect and track small UAVs.
-- Collect small UAV signatures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

FY 2009 Plans:
-- Develop target tracker.
-- Validate classifier performance.
-- Exercise full processing chain.
-- Integrate kill mechanism.

	FY 2007	FY 2008	FY 2009
Advanced Radar Sensor Technology	12.000	14.000	18.000

(U) The Advanced Radar Sensor Technology thrust develops radar systems to provide significant improvements in our ability to detect, identify, and track surface targets and threats over very wide areas in all climatic conditions. Program efforts focus on exploiting emergent and novel radar sensing technology and phenomenology. Key elements are advancements in ultra-wide band, bistatics, UHF/VHF, polarimetric change detection, tomographic imaging, space-time adaptive processing and other advanced signal processing, advanced Ground Moving Target Indication techniques, and foliage, building-penetrating, and ground-penetrating radar phenomenology. Program developments are integrated with current and emerging military platforms. Emphasis is on the most stressing military radar sensor challenges. Examples are operations featuring complex cluttered ground environments; those against small and slow moving surface targets; urban operations, and situations where camouflage, decoys and countermeasures must be overcome. Programs in this thrust include:

- The Augmented Aerial Sentry (AAS) program designed a rapidly-deployable airborne system to provide assured protection of permanent or temporary U.S. base camps in hostile territory. AAS could accommodate ground-based, wide area sensors in conjunction with air platforms to maintain continuous surveillance of the area around the camp, detecting potential intruders or weapon launches. The suite of airborne sensor platforms could then be tasked locally to investigate potential threats; lock on to personnel or weapons involved in an attack; allow commanders to confirm threats; or authorize precision weapons to engage them.

- The Sensing and Exploitation of Urban Movers (SE-UM) program develops technology for the detection of dismounted troops in combat situations using airborne radars. SE-UM develops the capability to detect, classify, track and recognize the behavior of human beings using radar data. Existing radars have been shown to allow this capability under ideal circumstances; those under development will, either fortuitously or by design, more consistently obtain detections from individuals. SE-UM will exploit these data by detecting each

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

individual, classifying the individual as human and according to their speed and gait, tracking many individuals (forward and backwards in time) and automatically recognizing common, anomalous and significant actions/behaviors. Challenges include detection of motion below the minimum discernable velocity of the radar system, and discernment of multiple moving objects within a single beam width. Using SE-UM on data from appropriately designed airborne radar the system could observe human motion over an entire urban region. SE-UM technologies will transition to the airborne systems deployed by the Air Force and Navy.

- The NetTrack program will extend capabilities for persistent tracking and targeting of moving vehicles from airborne radars. NetTrack will improve capabilities in two ways: the system will network radars together and use advanced radar techniques to gather "signatures" of vehicles. The signatures, which are collections of radar features, will be stored and passed over the radar network. The system will compare vehicle signatures taken before and after confusing events to maintain the track of the target vehicles. Extended long-term airborne radar tracking will be an important long-range, all-weather, capability. It will extend the kill chain to enable vehicle engagement hours after target designation, enable behavioral analysis of vehicle movements to gauge enemy operational structure, force composition, and intentions, and provide a higher level of situational awareness at every level. Technologies are planned for transition to the Navy, Army and Air Force.

- The Dual Beam Lynx program will enhance the capabilities of the Lynx radar system to track slow-moving vehicles more accurately. The program modifies a Lynx I radar to create two beams with different phase centers and uses space time adaptive processing to detect moving targets in the main beam clutter. The goals of this program include demonstrating improvement in minimal detectable velocity, improving geolocation accuracy, and achieving a low manufacturing cost. The radar performance will be demonstrated from flight data collected from the radar flying on a UAV surrogate. Technology is planned for transition to the Air Force.

- The Boreal program will develop and demonstrate a rapidly deployed, wide-area surveillance system for detection, tracking, precision location and engagement of high value targets under dense foliage. The Boreal system would be installed on a high flying fixed wing aircraft, and would rapidly search large areas for fixed and moving targets under foliage and provide simultaneous Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR). The GMTI will detect and locate dismounts and vehicles moving under foliage and the SAR will for reveal buildings, vehicles and lines of communications under foliage. The goals of this program include demonstrating real-time onboard wide-area GMTI and simultaneous SAR and achieving precise geolocation (7-10m) of moving dismounts. This technology will transition to the Air Force.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

- The Next Generation RF Antenna System program will develop and demonstrate an ultra-sensitive Radio-Frequency (RF) receiver made from lightweight non-reciprocal materials for precise direction and frequency sensing, tunable over a broad frequency range. This system will enable signals intelligence (SIGINT) at extended ranges by detecting faint or distant signals with accurate incident angle and frequency determination. The resulting system will provide greater than 10 dB improvement over existing amplifiers and antenna systems. This program is planned for transition to the Air Force by 2010.

(U) Program Plans:

– Augmented Aerial Sentry
FY 2007 Accomplishments:
-- Completed system architecture study.

– Sensing and Exploitation of Urban Movers (SE-UM)
FY 2007 Accomplishments:
-- Completed data collection, simulated data, dismounted characterization analysis.
FY 2008 Plans:
-- Conduct real-time demonstration.
FY 2009 Plans:
-- Transition to Air Force and Navy.

– NetTrack
FY 2007 Accomplishments:
-- Developed algorithms for radar feature association, radar tracking, long-term hypothesis management and sensor resource management.
-- Developed simulated test bed of vehicle movement in semi-urban areas to demonstrate the ability of radars to track ground moving vehicles.
-- Commenced integration of multiple components into tracker test bed.
FY 2008 Plans:
-- Improve capabilities for using vehicle radar signatures to associate vehicle observations.
-- Demonstrate NetTrack operations in simulation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

FY 2009 Plans:
-- Demonstrate radar signature-aided vehicle tracking, and the cooperative use between radar platforms of those radar features.
-- Demonstrate NetTrack capabilities in real-time on networked radar platforms.

– Dual Beam Lynx
FY 2008 Plans:
-- Conduct Preliminary Design Review.
-- Develop algorithms.
FY 2009 Plans:
-- Develop space time adaptive processing.
-- Perform flight test and data collection.

– Boreal
FY 2009 Plans:
-- Develop and test advanced signal processing algorithms.
-- Develop and test endbody design.
-- Collect data with non-real time non form-factor testbed and use this data to validate performance predictions.

– Next Generation RF Antenna System
FY 2009 Plans:
-- Model and simulate of materials to assess and optimize non-reciprocal behavior.
-- Fabricate and test 1-D material sample.
-- Extend non-reciprocal materials to detect radiation at oblique angles and to determine incident radiation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Sensor Technology; PE 0603767E, Project SEN-02

	FY 2007	FY 2008	FY 2009
Advanced Airborne Optical Sensing	22.950	22.100	29.385

(U) The Advanced Airborne Optical Sensing thrust develops large aperture sensors and image processing systems to provide video coverage of large areas and detection and identification of elusive targets at long range and under foliage and camouflage. It builds optics, gigapixel focal plane arrays, advanced laser radar technologies, embedded image processors, and video compression algorithms tailored to real-time detection, identification, and tracking of military targets. It emphasizes materials and phenomenologies suitable for operations at night and with significant atmospheric absorption or obscuration due to foliage and camouflage. Programs in this thrust include:

- The Standoff Precision ID in 3-D (SPI 3-D) program is developing an affordable sensor package capable of high-resolution 3-D images for confirmatory target ID at long ranges (>10km) as well as full field of view (FOV) ranging to support precise geolocation of targets. The system provides intensity, range and polarization information for each pixel in the field of view with each laser pulse. The program includes a series of ground-based and airborne demonstrations of SPI-3D precision ID capabilities and track fusion techniques. The objectives are to provide: (1) high range resolution 3D imaging; (2) full FOV range to pixel determination; (3) multiple frame-to-frame registration of imagery, and (4) GPS-based cueing from search systems. Results will provide commanders with significantly improved long-range identification of enemy ground targets, as well as targeting information to support coordinate guided weaponry. The SPI-3D system employs optics and focal plane arrays and gimbals combined with a novel Pockels cell range measurement technique. The system will operate in the near infrared spectral region to minimize observability. SPI-3D technologies are being designed to achieve a Class IV UAV-compatible (Predator, Firescout & Warrior) configuration for installation into a Multi-spectral Targeting System (MTS) turret for transition to the Air Force at the conclusion of Phase III, which is anticipated to be completed by FY 2010. The program will also aid in Geiger Mode Avalanche Photodiode (GmAPD) technology transfer for the production of high speed, ultra sensitive photodetectors to systems requiring operation at very low photon counts. This will support long range sensors that can detect highly obscured targets (≥ 95%) under canopy/camouflage.

- The Advanced Optical Sensing program develops the next generation of airborne optical surveillance systems while also developing and demonstrating the ability to obtain very high dynamic range, high resolution hyper-spectral and polarimetric information from airborne imagers. The program focuses on bringing recent advances in photonic and other technologies to military airborne optical sensing systems. This effort develops advanced digital signal processing to support onboard image reconstruction, atmospheric correction and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

system calibration. Techniques are being explored to realize a large aperture wide-field-of-view imaging system within less than half a meter of thickness. Adaptive optics techniques, such as those used for atmospheric correction, are being explored to help combine sub-apertures while relieving alignment requirements. While electronic beam steering and zoom optics have been demonstrated with deformable mirrors and liquid crystal spatial light modulators, this program seeks to extend these technologies and make them practical for airborne surveillance systems. Technologies are planned for transition to the U.S. Army.

- The Large Area Coverage Search-while-Track and Engage (LACOSTE) program enables persistent tactical-grade Ground Moving Target Indication (GMTI) in dense urban areas. Wide-area continuous tracking of moving vehicles requires very small coverage gaps, small resolution cells, and target separation and identification features. The ideal sensor has the area coverage rates of GMTI radar and the resolution/identification capabilities of an electroptical infrared system. The LACOSTE program will provide wide area surveillance, simultaneous tracking, and target engagement with optical and infrared sensors for tactical GMTI operations. The program is developing a sensor with a very wide field of regard (90° cone angle), and a wide instantaneous field-of-view (FOV) that is rapidly scanned in a search-while-track mode – tracking up to 10,000 targets in an urban area. Additionally, the LACOSTE sensor will provide next-generation precision tracking to enable engagement on a large number (~100) targets in dense urban areas within that same field of regard with a minimal penalty on the search-mode area coverage rate. The program is also developing a rapid "zoom" capability for target identification that enables feature-aided tracking through dense target environments plus sufficient target identification for separating like-targets when back-tracking a particular target via the historical track data. The LACOSTE technology is planned for transition to the Air Force and the Army at the conclusion of the program anticipated in FY 2009.

- Spatially Processed Image Detection and Ranging (SPIDAR) is a coherent imaging method that allows one to form a large effective optical aperture from a set of smaller, lighter telescopes providing for very high-resolution 3-D and 2-D ladar imagery of distant targets with a compact system configuration. This capability is very well suited for long-range engagements from airborne or space-based platforms and could significantly enhance the current synthetic aperture imaging approaches by providing the desired cross-range resolution along the axis perpendicular to the direction of travel. This capability is also applicable on a small scale to provide very high resolution imagery in a compact and potentially man-portable configuration for long-range ID. The gain in size, weight and power over more conventional lidar implementations will be assessed and demonstrated. The effort will improve performance of the technology, specifically using diffuse reflective targets, targets with lower contrast and reduced intensity reference beam. Additionally, suitable missions and platforms for the technology will be identified. SPIDAR technologies will be transitioned to the Air Force in FY 2013.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

- The Hyperspectral Framing program will develop and demonstrate a system for collecting and processing hyperspectral (HSI) data operating as a framing sensor, instead of as a line scanner with the constraints of current sensors. The system will accept wide spectral content over hundreds of bands permitting extremely powerful air and space-borne reconnaissance for real time target detection. The resulting sensor and processing system will provide a 2-3 order of magnitude increase in the combination of area coverage rate and resolution, as well as a 1-2 order of magnitude decrease in sensor system size and weight and power consumption. The Hyperspectral Framing system is planned for transition to the Air Force by FY 2010.

(U) Program Plans:

– Standoff Precision ID in 3-D (SPI-3D)
FY 2007 Accomplishments:
-- Initiated preliminary design of components for integration into a Multi-spectral Targeting System (MTS) turret and flight testing of selected critical design elements.
FY 2008 Plans:
-- Complete design for integration into MTS turret.
FY 2009 Plans:
-- Critical Design Review and fabrication of flight sensor components and flight system development.

– Advanced Optical Sensing
FY 2007 Accomplishments:
-- Investigated approaches for producing large aperture imaging systems with constrained size.
-- Explored uses of adaptive optics to provide optical corrections for multiple sub-apertures.
FY 2008 Plans:
-- Investigate technologies for optical beam steering and optical zoom that can be applied to airborne optical systems.
-- Develop advanced signal processing techniques for the rapid formation of optical imagery.
FY 2009 Plans:
-- Integrate into test vehicle.
-- Conduct flight experiments for video windows and video tracking.
-- Transition system to Services for production and fielding.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Sensor Technology; PE 0603767E, Project SEN-02

– Large Area Coverage Search-while-Track and Engage (LACOSTE)
FY 2007 Accomplishments:
-- Developed objective system concepts enabling wide-area stand-off sensor for urban tactical-grade ground target tracking.
-- Developed electroptical infrared electronically scanned sensor components.
FY 2008 Plans:
-- Lab test the sensor parameters against measured urban data.
-- Develop optical tracking algorithms.
-- Design and develop scaled objective system.
FY 2009 Plans:
-- Manufacture and integrate the LACOSTE sensor components.
-- Conduct a rooftop demonstration of a large cone-angle electronically scanned sensor in an urban environment.

– Spatially Processed Image Detection and Ranging (SPIDAR)
FY 2009 Plans:
-- Initial assessment of the performance of the current system configurations and systems analysis of long-range, high-resolution imaging applications.
-- Identify the trade space for considering multi-aperture receivers and illuminators in the system designs.
-- Define and detail performance of underlying key component technologies (including stable, high-power laser sources, high-speed imaging focal planes and image processing analysis.).
-- Develop conceptual system designs to achieve desired system performance.

– Hyperspectral Framing
FY 2009 Plans:
-- Detailed design of hyperspectral sensor package.
-- Parallel processing algorithm development.
-- Laboratory demonstration of breadboard system.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

	FY 2007	FY 2008	FY 2009
Synthetic Aperture Ladar for Tactical Imaging (SALTI)	13.689	14.000	26.000

(U) The Synthetic Aperture Ladar for Tactical Imaging (SALTI) program develops and demonstrates an airborne synthetic advanced laser radar (ladar) imager capable of producing high-resolution three-dimensional imagery at long ranges. The technical objective of the SALTI program is to provide a proof-of-concept for operation at tactically relevant high altitudes and at long ground ranges. The SALTI approach combines the long-range day/night access afforded by conventional synthetic aperture radar with the interpretability of high-resolution optical imagery and the exploitability of three-dimensional imagery, for deployment within a tactical-sized package. The SALTI program has produced the first-ever synthetic aperture LADAR images from aircraft. Development and demonstration of long range performance is scheduled to be conducted through FY 2009. The SALTI technology is planned for transition to the Air Force by FY 2012.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed sensor package and ground testing.
- Conducted flight testing in various operational environments.

FY 2008 Plans:

- Develop lasers for higher power and higher bandwidths to support Long Range Demonstration (LRD).
- Characterize propagation through the atmosphere under operational conditions to assess long range operational performance.
- Generate and modify system design to support LRD.

FY 2009 Plans:

- Commence fabrication of critical subsystems to increase transmit power and telescope aperture.
- Repackage to reduce size and weight.
- Increase field-of-regard to allow forward look angles and accommodate aircraft roll and pitch.
- Develop real-time onboard processor and test critical subsystems.
- Test and characterize SALTI performance against diverse target sets in representative scenarios.
- Modify system design to support installation and testing in a pod.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

	FY 2007	FY 2008	FY 2009
Ground Targeting Sensors	15.815	17.540	17.602

(U) The Ground Targeting Sensor thrust provides sensors and signal processing systems to detect, identify, and engage close-in ground targets. Its products are installed on platforms that operate on the ground (HUMVEE, convoy elements) and near the ground (helicopters). They employ technologies that defeat or compensate for the unusual atmospheric conditions near the surface (turbulence, dust, strong propagation losses) in order to provide timely and accurate detection and classification of dismounts, small vehicles, and terrain obstacles. Programs in this thrust include:

- The SandBlaster program will develop a passive pilot enhancement system that fuses visible, infrared (IR) and millimeter wave radiation to enable multiple helicopters to land safely in conditions of severe brown- and white-out. SandBlaster will exploit the low attenuation property of dust (fog and snow) on millimeter wave radiation. A passive millimeter wave system will be developed to preclude detection and prevent interference as would be expected from multiple active systems operated in close proximity. Four fundamental piloting situational awareness enablers will be addressed: (1) pilot's ability to "see" in limited visibility conditions, (2) pilot's awareness of helicopter drift, (3) pilot's awareness of slope of terrain, and (4) display technology matched to mission and human factors considerations. The technology developed under this program will transition to SOCOM and the Marine Corps in FY 2008.

- The Super-Resolution Vision System (SRVS) program will develop and build a field prototype soldier-portable optical system that will demonstrate improved recognition and identification range over existing systems. The key technical innovation is exploitation of atmospheric turbulence-generated micro-lensing phenomena to generate images that are superior to diffraction-limited images. SRVS will facilitate new operational and tactical opportunities for land forces. Through enhanced resolution imaging, SRVS will (1) extend target recognition and identification to decisively longer distances; (2) overcome atmospheric turbulence, which now limits the ability of high-resolution optics; and (3) increase target identification confidence to reduce fratricide and/or collateral damage. It will culminate in a field demonstration of a prototype. Technology developed under this program will transition to Special Operations Forces in FY 2011.

- Polar Bear will provide a missile seeker that uses polarimetric processing and 3-D registration with target folders to generate precision terminal guidance. The system will sense polarimetric long-wave infrared signals generated by target and background, derive the surface shapes of the target and background and match the target shape to 3-D target folders. This will enhance target identification capabilities

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

and enable precision aim-point selection on the target. The program will develop algorithms for surface normals and shape signature extraction from polarimetric data, develop tools for 3-D target folders, and develop software for real time onboard processing. The precision attainable by Polar Bear will be suitable for a kinetic-kill weapon and the sensor cost will be comparable to existent uncooled infrared missile sensors. Technologies are planned for transition to the U.S. Army.

- The Short Wave Infrared through Fog and Clouds (SWIF) program will develop and demonstrate advanced signal processing and optical imaging technology to allow detection of collision and grounding threats in fog and clouds at useful ranges (day or night). The obscurants substantially degrade performance in precision handling operations. Humans are able to operate successfully with sensor assistance, but situational awareness significantly degrades. Successful development of this technology will restore this situational awareness to tactically relevant distance and time scales. Significant technical obstacles that must be overcome include development of an ultra-short pulse laser with sufficent bandwidth and fast enough pulse rise time to create transient-like propagation characteristics in an aerosol cloud. This effort is planned for transition to the Navy and Air Force by FY 2012.

(U) Program Plans:

– SandBlaster
  FY 2007 Accomplishments:
  -- Completed full scale lidar testing of helicopter dust cloud penetration, and landing zone imaging.
  FY 2008 Plans:
  -- Complete Millimeter-Wave Radar development.
  -- Complete synthetic vision development.
  -- Complete advanced control laws.
  -- Complete sensor fusion engine.
  -- Complete development system integration and flight testing to demonstrate capabilities and performance.
  -- Integrate the system and demonstrate capabilities.
  -- Transition to the Services at completion.

– Super-Resolution Vision System (SRVS)
  FY 2007 Accomplishments:
  -- Established baseline soldier performance in turbulent atmospheres.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

-- Conducted field experiments to obtain data for algorithm development.
-- Developed image formation algorithms.
-- Tested image formation algorithm performance in controlled field experiments.
-- Designed prototype system.

FY 2008 Plans:
-- Investigate optimal control algorithms and implementation.
-- Complete prototype design; fabricate brassboard system.
-- Conduct field experiments and testing to optimize system performance.

FY 2009 Plans:
-- Complete fabrication and testing of soldier portable prototype.
-- Conduct demonstration and testing of prototype systems.
-- Modify design based on experiments and testing to support transition.

– Polar Bear

FY 2008 Plans:
-- Conduct long-wave infrared measurements of various targets over a range of employment conditions, including geometry, lighting, obscurants, etc.
-- Develop and evaluate polarimetry-based 3-D registration algorithms.

FY 2009 Plans:
-- Develop algorithms and exploitation tools for target folder development based on processed sensor data.
-- Conduct preliminary design review for a Polar Bear enabled missile seeker to be built and demonstrated.
-- Develop a concept for operations and identify transition opportunities for the Polar Bear seeker technology.

– Short Wave Infrared through Fog and Clouds (SWIF)

FY 2008 Plans:
-- Develop imaging algorithms.
-- Conduct modeling and simulation to optimize system range and resolution.
-- Design scanning and imaging system for fast image formation in a wide field of view.
-- Conduct experiments under various scattering and absorption conditions to characterize optical link budget.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

-- Demonstrate imaging algorithm performance in controlled conditions.

FY 2009 Plans:

-- Design prototype system.
-- Test brassboard system in various operating conditions.
-- Develop prototype system.
-- Conduct environmental performance testing of prototype system.

	FY 2007	FY 2008	FY 2009
Soldier-borne Sensor Technology	15.273	9.046	11.997

(U) The Soldier-borne Sensor Technology thrust provides sensors for improved situational awareness and effectiveness of individual soldiers. It builds small unit enemy weapon fire detection and classification tools, more precise target designation sensors, and methods for improved small arms weapon effectiveness. Programs in this thrust include:

- The High Precision Long Range Laser Designator/Locator (HPLD) program seeks to develop an affordable laser target designator/locator package that allows the user to observe, track, and designate a target at operationally significant ranges. The focus of this effort is to investigate target-in-the-loop active optics approaches and novel high accuracy pointing methods to enable a single operator to precisely determine the GPS coordinates of a target that is multiple kilometers away. Once precisely determined, the operator would be able to observe, track, and laser designate the target as required, using a single device. This device would be used by ground combat elements and small unmanned aerial vehicles that conduct terminal attack control and call for fire and will be designed to support their full range of deployment methods. It also survives in a harsh environment for long periods of time with minimal maintenance. This program will also investigate advanced, lightweight inertial navigation system (INS) technology, infrared imaging and advanced on-focal-plane processing technology to achieve revolutionary improvements in targeting device form factor, speed, cost and accuracy as well as technologies that could assist snipers and spotters. This technology is expected to transition to the Army.

- The Omni-Directional Flash & Launch Detection, Positioning, Classification and Observation System (MEGA) program will develop a low-cost, omni-directional staring, infrared sensor, which will provide circumpheral imagery of its surroundings. The MEGA sensor and algorithms will be used to detect weapon discharges in its field of regard, locate and classify them and, using appropriate communication

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

means, convey the information to other units or systems connected to it. This program will transition through delivery of two final 360 degree mobile systems to Service partners.

- The Crosswind Sensor System for Snipers (C-WINS) program will build upon technology investigated under the HPLD program and provide optical techniques to correct for crosswinds on ballistic objects. The C-WINS System will develop a novel weapon mounted laser correction system for various rifles and machine guns. This laser will be directed downrange for wind profiling and ballistic correction. The new system will provide offset corrections to the shooter for compensating the aim point affected by the crosswind. Key parameters of interest are: a) bullet strike coordinates less than the target size at any range up to weapons effective range; b) down range profiling up to weapons effective range; c) ranging accuracy sufficient to offset; d) automatic ballistic correction; e) day/night operation; and f) no setup or calibration. Additional capabilities could include: increased effective ranges for a wide range of weapons; eye safe ranging; illumination when combined with night sight; combat ID; and point-to-point voice communications. This program is planned for transition to the Army and Marines in 2010.

- The Laser Geospatial Referencing (LGR) system will allow ground troops to designate targets for engagement by air forces where the pilot or UAV operator can see the designated spots within the field of view of their visible or forward looking infrared system. The LGR concept provides nearly instantaneous target location, identification and designation capabilities to weapon platforms supporting urban or other ground operations. The LGR concept enables these assets to be immediately directed by dismounted soldiers. LGR technology could dramatically reduce the time required for targeting existing firepower in the form of man-portable missiles, light armor, tanks, artillery and ground attack aircraft. LGR technologies will be transitioned to the U.S. Army and Marine ground forces, and U.S. Air Force and Army Airborne Targeting Systems in FY 2013.

- The Sensor Tape program will develop and demonstrate a low-cost one-time-use low-power band-aid size adhesive-applied blast dosimeter that records accumulative blast effects for integration into combat medical care. Significant technical obstacles that must be overcome include achieving adequate switching frequencies, packaging, print-on ink technologies and production costs. Sensor Tape is planned for transition to the Air Force by FY 2011.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

(U) Program Plans:

– High Precision Long Range Laser Designator/Locator (HPLD)
FY 2007 Accomplishments:
-- Completed image resolution & dance data analysis.
-- Developed signal processing technologies and algorithms to achieve high resolution imaging and reduce laser beam dance and wander.
-- Built and demonstrated target-in-the-loop adaptive optics ability to achieve high resolution laser pointing and imaging of small targets.
-- Developed atmospheric turbulence statistical model and investigated commercial off-the-shelf (COTS) lasers to test alternative concepts by modeling.
-- Developed system concepts for snipers and spotters that rely on tracking the aerosol motion resulting from crosswind over time.
FY 2008 Plans:
-- Demonstrate the feasibility of measuring crosswind and turbulence.
-- Investigate technology solutions to mitigate the effects of weather on sighting systems.

– Omni-Directional Flash & Launch Detection, Positioning, Classification and Observation System (MEGA)
FY 2007 Accomplishments:
-- Developed and demonstrated IR sensor prototype.
-- Developed and demonstrated stationary omni system.
-- Developed and demonstrated mobile platform omni system.
FY 2008 Plans:
-- Integrate mobile system with vehicle and demonstrate in series of field tests.

– Crosswind Sensor System for Snipers (C-WINS)
FY 2009 Plans:
-- Design and build an electronics board sufficient to trigger laser at required rates, receive, store and process data (on line and offline).
-- Integrate system and conduct field tests to validate the proposed concept as a function of the crosswind and scintillation index.
-- Demonstrate system capability to correct crosswind effects on ballistic trajectory.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02

-- Develop transition and manufacturing plans.

– Laser Geospatial Referencing (LGR)
FY 2009 Plans:
-- Complete analysis of radiometric constraints and the available technology paths to meet the program objectives.
-- Complete limited measurements of narrowband, wide field of view filters, and snapshot "shutters" suitable for the system as envisioned in turret and targeting pod configurations.

– Sensor Tape
FY 2009 Plans:
-- Develop jet-printing processes required for printed sensors, printed electronics and printed memory components.
-- Develop printed pressure, acceleration, light and acoustic sensors.
-- Develop and demonstrate proposed sensors and communications capability in controlled laboratory experiments.
-- Integrate modules into a complete first generation prototype blast dosimeter.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Guidance Technology; PE 0603768E

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	127.170	124.974	110.572	80.238	83.804	92.713	92.719
Guidance Technology GT-01	49.808	44.856	41.125	30.225	29.718	29.718	29.717
Classified GT-CLS	77.362	80.118	69.447	50.013	54.086	62.995	63.002

(U) Mission Description:

(U) The Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing system oriented technologies that will improve our ability to navigate weapon systems with more precision and increase the capability to meet current and emerging threats.

(U) The Guidance Technology project will increase the ability of Global Positioning System (GPS) users to operate effectively in the presence of enemy jamming; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems. Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this project.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	142.826	127.777	121.704
Current Budget	127.170	124.974	110.572
Total Adjustments	-15.656	-2.803	-11.132
Congressional program reductions	-12.000	-2.803	
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	-3.656		

(U) Change Summary Explanation:

FY 2007	Decrease reflects the Section 8043 Recission and the SBIR/STTR transfer.
FY 2008	Decrease reflects reductions for Section 8097 Contractor Efficiencies, Section 8104 Economical Assumptions, and Section 8025(f) FFRDCs.
FY 2009	Decrease reflects program rephasings in Project GT-CLS, offset by expansion of guidance technologies in Project GT-01.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Guidance Technology GT-01	49.808	44.856	41.125	30.225	29.718	29.718	29.717

(U) Mission Description:

(U) Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. Thrusts are included in this project to improve our ability to navigate when the Global Positioning System (GPS) is jammed or otherwise unavailable; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Multifunctional Electro-Optics for Defense of U.S. Aircraft (MEDUSA)	13.005	15.000	15.669

(U) The Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program will develop the technologies and systems to give the U.S. air dominance at low altitude and at night. This program will develop the technologies to leap-frog reactive end-game countermeasures and enable increased threat warning times, denial of launch, and put Electro Optical-Infrared (EO-IR) air defense threats at risk. MEDUSA is a three-part technology program: (1) conduct phenomenological measurements and develop countermeasures and target classification/identification techniques; (2) develop critical component technologies such as high-power IR laser sources, advanced IR detectors, and fibers for high-power IR transmission; and (3) develop and demonstrate an end-to-end MEDUSA system. The MEDUSA technology is planned for transition to the Air Force and Army at the conclusion of technology development and flight demonstration, which is anticipated to be completed during FY 2011.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01

(U) Program Plans:

FY 2007 Accomplishments:

- Initiated development of high-performance 128x128 focal plane arrays (FPAs) to enable the MEDUSA missions.
- Completed design of the Read-Out Integrated Circuit (ROIC) enabling extremely low-power, high-sensitivity (>300 gain), high-speed (>10 kHz frame rate), high-bandwidth (>100 MHz) features for an active receiver in the Near/Mid-Wave Infrared (NMIR) regime.
- Completed design of the ROIC enabling low-power, high-sensitivity, high-speed features for an active receiver in the LWIR regime.
- Fabricated initial NMIR high-speed, low-power, 128x128 ROIC and performed a design validation test of performance.

FY 2008 Plans:

- Fabricate first fully integrated large format 128x128 NMIR FPA integrated with a low-power, high-speed ROIC, demonstrating high-sensitivity and high-gain (>300) performance in an integrated FPA/ROIC compact camera cryo-cooler package.
- Fabricate final Long-Wave Infrared (LWIR) ROIC prior to hybridization with FPA.

FY 2009 Plans:

- Complete fabrication of first fully integrated large format 128x128 LWIR FPA integrated with a low-power, high-speed ROIC, demonstrating high-sensitivity large format heterodyne receiver performance in an integrated FPA/ROIC compact camera cryo-cooler package.

	FY 2007	FY 2008	FY 2009
Precision Inertial Navigation Systems (PINS)	9.259	6.000	4.000

(U) The Precision Inertial Navigation Systems (PINS) program will develop an entirely new class of inertial navigation instruments using atomic inertial force sensors. These sensors utilize the quantum-mechanical wave-like nature of atoms in the atomic analogue of an optical interferometer to provide unprecedented sensitivity to accelerations and rotations. The atomic sensors will further be used to measure the local gravitational field gradient to ensure that instrument alignment is properly maintained throughout vehicle maneuver, thus mitigating gravity-induced navigation errors. Initial program efforts will focus on developing fundamental technology components upon which future systems would be constructed. The PINS technology is planned for transition to the Navy and Air Force at the conclusion of Phase III, which is anticipated to be completed by the end of FY 2009.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated eight atom cloud, synchronous Inertial Measurement Unit (IMU) in a static environment providing position and angle output at 10 Hz update rate.
- Designed and assembled hardware test bed to evaluate system components in realistic operating environment.

FY 2008 Plans:

- Install stable platform for PINS IMU into ground vehicle for FY 2009 cross-country demonstration.
- Complete open-ocean test campaign with combat swimmers demonstrating <100 meter per hour submerged navigation error.

FY 2009 Plans:

- Demonstrate gravity-compensated atom cloud IMU in ground vehicle that accumulates <5 meters per hour integrated navigation error for path between Palo Alto, CA and Arlington, VA.
- Design and construct pre-production prototype for final evaluation by Marine Corps combat swimmers.

	FY 2007	FY 2008	FY 2009
Robust Surface and Sub-Surface Navigation (RSN/SSN)	12.044	12.000	9.456

(U) The Robust Surface and Sub-Surface Navigation (RSN/SSN) program will provide the U.S. warfighter with the ability to navigate effectively when the GPS is unavailable due to hostile action (e.g. jamming) or blockage by structures and foliage. The RSN/SSN program will use signals of opportunity and specialized signals from a variety of ground, air, and space-based sources and judiciously placed low frequency RF beacons; these will be received on the warfighter's forthcoming software defined radios and use specially tailored algorithms to determine position. Other signals such as the Earth's magnetic field (micro deviations), and cyclic variations in the Earth's gravitational field due to tidal motion, will also be evaluated. The greater strength and diversity of these signals will provide coverage when GPS is denied due to lack of penetration into buildings and underground, and when severe multipath is a problem. This is a two-part program: (1) cataloging and assessing of potential exploitable signals followed by analysis and performance modeling and hardware-based concept validation and (2) designing, testing, and demonstrating of a (non-form-fit) prototype receiver(s) and algorithms for geolocation using the signals of opportunity. The RSN/SSN technology is planned for transition to U.S. Special Operations Command, the U.S. Army and the U.S. Air Force by FY 2010.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01

(U) Program Plans:

FY 2007 Accomplishments:

- Evaluated feasibility of RSN candidate approaches using modeling, analysis, and simulation.
- Successfully demonstrated SSN beacon geolocation approach for underground navigation.
- Developed critical RSN/SSN technologies and conducted phenomenological measurements to validate the selected concepts.
- Completed design and component-level testing of SSN system.
- Developed and conducted performance analysis of innovative algorithms for SSN that enhanced form/fit of user receiver.

FY 2008 Plans:

- Design and fabricate prototype SSN system.
- Complete concept design of RSN systems.

FY 2009 Plans:

- Complete fabrication of RSN systems.
- Test functional prototype SSN system for underground use.

	FY 2007	FY 2008	FY 2009
Navigation-Grade MEMS Inertial Measurement Unit (IMU)	15.500	11.000	7.000

(U) The Navigation-Grade MEMS Inertial Measurement Unit (IMU) program will develop micro-scale accelerometers and gyros with navigation-grade performance that use only milli-watts of power. The program will transcend traditional single mass-spring methods for navigation sensing and will explore alternative approaches, such as multiple, interconnected mass-spring systems, micro-levitated spinning structures, micro-optical readout mechanisms, atomic interferometric readout mechanisms, and fluidic contortions. This program will transition to industrial performers by developing wearable inertial measurement units (IMUs) for dismounted warfighters capable of GPS-denied navigation for lengthy periods; small IMUs for unmanned air and underwater vehicles, and for guidance of small, long-range munitions—all of which will go into DoD systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01

(U) Program Plans:
FY 2007 Accomplishments:
– Achieved 3-D resonator structures (e.g., spheres, full wine-glass structures).
FY 2008 Plans:
– Develop levitation methods.
– Develop fluid contortion sensing.
FY 2009 Plans:
– Develop micro-environmental control.
– Control electronics integration.

	FY 2007	FY 2008	FY 2009
Active Electrol-Optical Mapping and Navigation System (AONS)	0.000	0.856	0.000

(U) The Active Electrol Optical Mapping and Navigation System (AONS) program will provide GPS-denied navigation and detailed building interior mapping to soldiers operating in urban environments. AONS will employ electro-optic system strengths in image registration and precision range to track and map a soldier's or vehicle's position continuously. Using image-flow methods, a compact, power-efficient camera and optional laser radar system will track the imagery from frame-to-frame and estimate camera pose and position information to provide the soldier a very precise determination of current position as well as a continuously updated map of the building or underground facility (UGF) being traversed.

(U) Program Plans:
FY 2008 Plans:
– Conduct feasibility study.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01

	FY 2007	FY 2008	FY 2009
COmpact Ultra-stable Gyro for Absolute Reference (COUGAR)	0.000	0.000	5.000

(U) The COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) program goal is to realize the fundamental performance potential of the resonant fiber optic gyro (RFOG) in combination with bandgap optical fiber (BGOF), ultra-stable compact lasers, phase conjugate elements (PCEs), and silicon optical benches: a compact ultra-stable gyro for absolute reference applications. The COUGAR gyro will have a practical and typical size (~ 4 inch diameter) featuring bias stability and sensitivity (or angle random walk), which is more than 100 times better than state-of-the-art gyroscopes.

(U) Program Plans:
FY 2009 Plans:
- Develop purely single-polarization low-loss, low glass-content BGOF.
- Demonstrate compact narrow line-width single-frequency laser technology with ultra-low jitter and the capability of extremely linear frequency scanning.
- Develop resonator-ready (low loss) PCEs for mitigating residual non-linear Kerr Effect errors and relaxing tolerances on laser intensity stabilization requirements.
- Develop silicon optical bench technology for optical ruggedization and a path toward a compact and affordable gyroscope.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Small Business Innovative Research PE 0605502E, Project SB-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	78.657	0.000	0.000	0.000	0.000	0.000	0.000
Small Business Innovative Research SB-01	78.657	0.000	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) This project explores innovative concepts pursuant to Public Law 106-554 (Small Business Reauthorization Act of 2000) and Public Law 107-50 (Small Business Technology Transfer Program Reauthorization Act of 2001), which mandates a two-phase competition for small businesses with innovative technologies that can also be commercialized. The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs will develop new dual-use technologies for possible future DARPA needs.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Small Business Innovative Research	78.657	0.000	0.000

(U) Program Plans:
FY 2007 Accomplishments:
- SBIR program being executed within OSD guidelines.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Small Business Innovative Research PE 0605502E, Project SB-01

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	0.000	0.000	0.000
Current Budget	78.657	0.000	0.000
Total Adjustments	78.657	0.000	0.000
Congressional program reductions	0.000		
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	78.657		

(U) Change Summary Explanation:

FY 2007 Increase reflects the SBIR/STTR transfer.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE DARPA Agency Relocation PE 0605897E, Project AR-02

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	0.000	0.000	28.000	45.000	0.000	0.000	0.000
DARPA Agency Relocation AR-02	0.000	0.000	28.000	45.000	0.000	0.000	0.000

(U) Mission Description:

(U) This PE is budgeted in the Management Support Budget Activity to meet building relocation support cost requirements for the Defense Advanced Research Projects Agency (DARPA). The move to a new facility is required by the Department of Defense Unified Facilities Criteria (UFC) and Anti-terrorism/Force Protection Requirements Regulation (UFC 4-010-01 dtd 8 OCT 2003, as amended 22 Jan 2007). The regulation lists force protection standards and is mandatory for facilities leased for DoD use. The regulation applies to all new leases executed on or after 1 OCT 2005 and to renewal or extension of any existing lease on or after 1 OCT 2009. DARPA's existing leased facility does not meet the UFC standards and the lease expires 30 JUL 2010. This PE will fund all expenses associated with planning and movement of the Agency to its new location. Initial costs will include design and trade studies, costs associated with implementing force protection standards, floor plan layout and planning activities leading up to the move. Further, it will fund outfitting of the selected property with the force protection standards, infrastructure, equipment, and furniture required for the DARPA staff and completion of the move in the 2010-2011 timeframe.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
DARPA Agency Relocation	0.000	0.000	28.000

(U) Program Plans:
FY 2009 Plans:
- Design and support GSA contracting for commercial construction of new facility.
- Implement force protection standards such as blast proofing and procure long lead items, vehicle barrier/entry control system, door and perimeter sensors, access control system and intrusion detection system for restricted areas.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE DARPA Agency Relocation PE 0605897E, Project AR-02

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

	FY 2007	FY 2008	FY 2009
Previous President's Budget	0.000	0.000	0.000
Current Budget	0.000	0.000	28.000
Total Adjustments	0.000	0.000	28.000
Congressional program reductions	0.000		
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	0.000		

(U) Change Summary Explanation:

FY 2009 The increase reflects building relocation support costs. This PE was established to separately identify all relocation expenses. Initial costs are budgeted in FY 2008 in PE 0605898E.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, Project MH-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	48.766	48.480	52.700	56.876	58.100	59.350	60.598
Management Headquarters (R&D) MH-01	48.766	48.480	52.700	56.876	58.100	59.350	60.598

(U) Mission Description:

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical security, travel, supplies and equipment, communications, printing and reproduction. During Base Realignment and Closure (BRAC) discussions, DARPA was instructed to work with the General Services Administration and Washington Headquarters Service personnel to prepare to vacate the Agency's current headquarters building at the end of its lease (2010) and relocate to a facility that meets force protection requirements. The FY 2008 budget includes funds to begin design and trade studies and initial floorplan layout. A new Program Element has been established for DARPA relocation expenses starting in FY 2009 (PE0605897E).

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Management Headquarters	48.766	48.480	52.700

(U) Program Plans:

FY 2007 Accomplishments:

- Funded civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.
- Funded travel, rent and other infrastructure support costs.
- Funded security costs to continue access controls, uniformed guards, and building security upgrades.
- Funded CFO Act compliance costs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, Project MH-01

FY 2008 Plans:
- Fund civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.
- Fund travel, rent and other infrastructure support costs.
- Fund security costs to continue access controls, uniformed guards, and building security upgrades.
- Fund CFO Act compliance costs.
- Fund Design and Trade studies in preparation for a move to a force-protection compliant building.

FY 2009 Plans:
- Fund civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.
- Fund travel, rent and other infrastructure support costs.
- Fund security costs to continue access controls, uniformed guards, and building security upgrades.
- Fund CFO Act compliance costs.

(U) **Program Change Summary:** *(In Millions)*	**FY 2007**	**FY 2008**	**FY 2009**
Previous President's Budget	48.766	52.992	63.700
Current Budget	48.766	48.480	52.700
Total Adjustments	0.000	-4.512	-11.000
Congressional program reductions	0.000	-4.512	
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	0.000		

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, Project MH-01

(U) Change Summary Explanation:

FY 2008 Decrease reflects transfer of funds for the Defense Agency Initiative financial system, and reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.

FY 2009 Decrease reflects the shift of funds to a new Program Element (PE 0605897E) for the building move.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA6 Management Support	R-1 ITEM NOMENCLATURE: Cyber Security Initiative; PE 0305103E, Project CYB-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	0.000	0.000	50.000	50.000	10.000	10.000	10.000
Cyber Security Initiative CYB-01	0.000	0.000	50.000	50.000	10.000	10.000	10.000

(U) Mission Description:

(U) This program element funds the Cyber Security Initiative. Details of this submission are classified.

(U) Program Accomplishments/Planned Programs:

	FY 2007	FY 2008	FY 2009
Cyber Security Initiative	0.000	0.000	50.000

(U) Program Plans:
FY 2009 Plans:
– Details will be provided under separate cover.

(U) Program Change Summary: *(In Millions)*	**FY 2007**	**FY 2008**	**FY 2009**
Previous President's Budget	0.000	0.000	0.000
Current Budget	0.000	0.000	50.000
Total Adjustments	0.000	0.000	50.000

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Cyber Security Initiative PE 0305103E, Project CYB-01

Congressional program reductions	0.000
Congressional increases	0.000
Reprogrammings	0.000
SBIR/STTR transfer	0.000

(U) Change Summary Explanation:

FY 2009 Funds were increased to support the Cyber Security Initiative.

(U) Other Program Funding Summary Cost:

- Not Applicable.