RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006

APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E

COST (In Millions)	FY 2005	FY2006	FY2007	FY 2008	FY 2009	FY 2010	FY 2011
Total Program Element (PE) Cost	196.594	186.746	205.519	221.442	219.805	205.919	190.919
Surveillance and Countermeasures Technology SEN-01	61.852	58.957	62.436	72.936	74.342	58.956	44.956
Sensors & Exploitation Systems SEN-02	134.742	127.789	143.083	148.506	145.463	146.963	145.963

(U) <u>Mission Description:</u>

(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.

(U) Additionally, this project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These technology developments are embodied in the following programs: Rescue Transponder; NUCTRAC; Visibuilding; Surveillance and Threat Neutralization in Urban Environments; Counter Underground Facilities; Hostile Fire Indicator; RF MEMS Improvement; Low Cost Cruise Missile Defense; Integrated Sensor Is Structure (ISIS); Speckle Exploitation for Enhanced Reconnaissance (SEER); Digital Radio Frequency Tag; and Wireless Vibration Sensor Initiative.

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(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. These needs are addressed by the following thrusts: Advanced Exploitation Systems Technology; Network Centric Sensing and Engagement; Advanced Optical Sensor Technology; and Advanced Radar Sensor Technology.

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

	FY 2005	FY 2006	FY 2007
Previous President's Budget	201.917	189.452	200.088
Current Budget	196.594	186.746	205.519
Total Adjustments	-5.323	-2.706	5.431
Congressional program reductions	-0.155	-2.706	
Congressional increases	0.000		
Reprogrammings	0.000		
SBIR/STTR transfer	-5.168		

(U) Change Summary Explanation:

FY 2005	Decrease reflects the DOE transfer for P.L. 108-447 and the SBIR/STTR transfer.
FY2006	Decrease reflects undistributed reductions for Section 8125 and the 1% reduction for Section 3801: Government-wide rescission.
FY 2007	Increase reflects minor shifts in program pricing and phasing.

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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 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Surveillance and Countermeasures Technology SEN-01	61.852	58.957	62.436	72.936	74.342	58.956	44.956

(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.

(U) Program Accomplishments/Planned Programs:

	FY 2005	FY 2006	FY 2007
Counter-Underground Facilities	18.000	14.000	20.436

(U) Underground Facilities (UGFs) are being increasingly employed to hide a variety of tactical and strategic functions, including command and control, leadership escapes and hides, missile and artillery protection, and activities associated with the manufacture and storage of weapons of mass destruction. The Counter-Underground Facilities (CUGF) program is developing technologies to both find and characterize UGFs: identification of facility function, pace of activity, pre-attack status of the facility, trans-attack activities and post-attack status. Techniques are being developed to determine locations of critical systems (power, water, airflow and exhaust vents), orientation and depth of structure, and pre-strike and post-strike changes in the substructure resulting from attack.

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(U) This program began by developing validated phenomenological models for a range of underground facilities (UGF) signatures: acoustic, seismic, electromagnetic (EM), chemical, multi/hyperspectral, and gravity/gravity gradient. These models enable the evaluation of multiple sensor/targeting concepts, and drive requirements for highly sensitive, advanced sensors, which operate at very low frequencies in order to reach deeply buried structures. One concept under development, the CUGF Unattended Ground Sensor System (CUGSS), will demonstrate the use of multiple, networked ground nodes of multi-phenomenological sensors (EM, acoustic, seismic) for UGF monitoring and target characterization. Another element, Effluents for Vent Hunting, has evaluated the feasibility of finding vents from stand-off locations by exploiting the spatial, spectral, and temporal characteristics of the exhaust plumes. The Low-Altitude Airborne Sensor System (LAASS), will demonstrate the use of airborne EM, acoustic, and gravity sensors to rapidly find UGFs and map out their backbone structure. Techniques are also being developed for finding and mapping traces and portals of small tunnels used for movement among large facilities or buildings, and for surreptitiously crossing borders and security boundaries. The CBT (Cross-Border Tunnel) program is using seismic and electromagnetic tomographly to detect and localize small tunnels. The RITA (Remote Interconnected Tunnel Assessment) program is using stand-off hyperspectral sensing to determine portals and vents that are connected by tunnels underground. Other potential technologies to be included are precision thermal imaging and active surface seismic and electromagnetic approaches. These are particularly useful for small, relatively shallow, unimproved tunnels.

(U) To support the demonstrations of these concepts, the CUGF program is also developing or modifying E-field, B-field, quantum, acoustic, and gravity-based sensors and enhancing navigation communications and signal-processing systems and technologies as necessary to meet the node-localization, communications and data-exfiltration requirements. The CUGF technologies are planned for transition to the United States Special Operations Command, the Defense Intelligence Agency, the Army and the Air Force in the FY 2008 time frame.

(U) Program Plans:

- Completed signature data collection and characterization of geophysical site properties of UGFs.
- Completed model validation for seismic, acoustic, electromagnetic and effluent signatures and backgrounds and for effluent modeling tools.
- Evaluated concepts for effluent-based vent hunting and cave exploration, and developed candidate sensor designs for effluent-based characterization.
- Demonstrated functional prototype of multi-mode/multi-node ground sensor system, using clutter-limited sensors.
- Demonstrated feasibility of rapid, airborne surveillance and mapping of UGF structures.

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- Developed component technologies for deployable systems, including low-mass coupling of seismic vibration sensors, site-adaptive non-line of sight communications, and improved deployable EM and gravity sensors.
- Conducted gravity gradiometer sensor and clutter performance measurements.
- Determined limits of performance of LAASS vs. altitude, sensor performance, and dwell time on target.
- Develop designs and performance predictions for prototype LAASS sensor payloads (EM, acoustic, and gravity) for UAV platform.
- Integrate LAASS sensor payloads onto low-altitude UAV platform and develop optimum flight pattern strategy.
- Demonstrate LAASS prototype system in rural and urban environments.
- Investigate the use of quantum sensing phenomena.
- Develop and demonstrate small tunnel finding, localizing, and endpoint mapping capabilities in the CBT (Cross-Border Tunnel) and RITA (Remote Interconnected Tunnel Assessment) programs.

	FY 2005	FY 2006	FY 2007
Visibuilding (Formerly Building Structure Activity and Assessment)	5.000	5.000	9.000

(U) The Visibuilding program will develop 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 can be used to image static structures directly. Doppler processing of radar signals can be used to find moving personnel within a building and also allow mapping of building pathways and stairways by monitoring traffic through buildings. Doppler resonances of the building structure may also provide relevant mapping information and indications of floor loading. Multipath and propagation effects can be 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 will develop 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. In addition, it will demonstrate technologies to monitor the integrity of building envelopes, to identify a breach of previously sealed/secured buildings and to identify previously hidden above and below-ground connections between buildings; approaches include pressure and power-line monitoring as well as the use of tracer gases deployed by hand or by robotics, such as multiple miniature search and rescue probes consisting of simple ball-like robots with rolling and hopping capability for building and rubble penetration. Transition to the Army’s PEO Soldier and United States Special Operations Command is planned for FY 2008.

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(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 will be a small sensor with a simple interface that will weigh less than two pounds including batteries. The unit will detect 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 for testing in theater is planned for FY 2006, with eventual transition to PEO Soldier.

(U) Program Plans:

- Visibuilding
  - -- Evaluate candidate designs for wall-penetrating technologies for building layout and combatant localization.
  - -- Evaluate candidate technical approaches for monitoring building envelope integrity.
  - -- Evaluate technical approaches for building interconnects detection and assessment.
  - -- Carry out feasibility measurements and modeling.
  - -- Design, build, and test prototypes for use in full-scale demonstration.

- Radar Scope
  - -- Evaluate candidate designs for through-wall motion detection.
  - -- Carry out feasibility measurements and modeling.
  - -- Design, build, and test prototypes for use in full-scale demonstration.

	FY 2005	FY 2006	FY 2007
Surveillance and Threat Neutralization in Urban Environments	4.000	4.000	8.000

(U) This program will develop systems 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 under development include intercept and localization of unintentional radiated emissions of remote-control circuits; multi-static radars for standoff identifications of shrapnel-packed bombs; detection of anomalies in vehicle dynamics;

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standoff identification and localization of explosive vapors/effluents; high fidelity 3D mapping performed from a high altitude (>15,000 feet) airborne platform; and multi-mode integrated acoustic and radar-based systems to backtrack to the source of fire. An additional technology thrust includes developing remotely powered sensors, which are passive and covert until probed with a single laser source. Neutralization technologies include targeted RF jamming of triggers; techniques to cause incomplete detonation of explosives; portable fast-erecting blast shields; and technologies to non-destructively and reversibly control urban access routes. 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 2008.

(U) Program Plans:
- Evaluate candidate technologies for wide-area/standoff and choke-point/portal-screening applications.
- Prove feasibility in lab on sub-scale tests.
- Design, build, and test prototype for choke-point applications and wide-area applications.

	FY 2005	FY 2006	FY 2007
Integrated Sensor Is Structure (ISIS)	11.000	18.000	0.000

(U) The ISIS program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship and 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 AMTI (600km) and GMTI (300km) operation; 12-plus months of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; plus CONUS-based sensor analysis and operation. The ISIS technology is planned for transition to the Army's PEO-ASMD, Air Force Joint Warfighter Space and the Missile Defense Agency at the conclusion of Phase IV which is anticipated to be completed by FY 2011. Beginning in FY 2007, this program will reside in PE 0603287E, project SPC-01.

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(U) Program Plans:

- Developed objective system concept designs enabling simultaneous AMTI and GMTI operation, one year logistics-free operation, 99% on-station availability, and high-bandwidth covert communications.
- Identified specific mass-reducing technologies for key radar, power, and airship components.
- Develop, mature, and demonstrate lightweight technologies for system integration (i.e. high-energy density batteries, electronic circuits on thin-film barrier materials, advanced multi-purpose airship hulls, regenerative fuel technologies).
- Design and simulate new radar modes: tracking air and ground targets through the clutter notch; detection and response to rockets, artillery, and mortars (RAM); detection of dismounted enemy combatants; and “track-all-the-way” fire-control.
- Design, build and demonstrate a fully-operational scaled flight system demonstrating complete system integration over an extended period (~3 months).

	FY 2005	FY 2006	FY 2007
Nuclear Facilities and Materials Tracking Assessment (NUCTRAC)	0.000	5.000	9.000

(U) The goal of the Nuclear Facilities and Materials Tracking and Assessment (NUCTRAC) program is to develop new technologies and systems that advance and enhance DoD capabilities in the area of hostile nuclear activities. The short-term goal of this effort is to solicit designs for the detection of fissile and radioactive materials, weapons programs, intact weapons and potential precursors for production of nuclear Weapons of Mass Destruction (WMD). The long-term goal of this effort is to enable robust detection of covert nuclear programs, nuclear weapons or materials en route to the United States, protection of U.S. interests overseas, and improvement in monitoring and inspection regimes. Specific objectives of NUCTRAC are to apply technology advances in computing, information processing, data fusion, low cost manufacturing, telecommunications, nanotechnology, robotics, signature detection, remote interrogation, facility characterization, mobile sensors, autonomous radiation detection technology and other recent advances to the detection of fissile materials, nuclear weapons and programs.

(U) Program Plans:

- Solicit detector concepts and develop to a level usable in Phase II development.
- Develop NUCTRAC preliminary design, risk management plan, and technology and system maturation plan.

– Develop sufficient system concept fidelity to validate program goals and objectives.

	FY 2005	FY 2006	FY 2007
Hostile Fire Indicator (HFI)	0.000	3.957	8.000

(U) The Hostile Fire Indicator (HFI) program will develop 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 in the vicinity of the crew cabin or some other critical and monitored system. The HFI system was initially 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. Based on the successes achieved thus far, the application of this program will be extended to the development of a portable system for use by the individual soldier. The HFI technology is planned for transition to USSOCOM by the end of FY 2010.

(U) Program Plans:

– Measure background noise on one U.S. Army and two SOF helicopters.
– Demonstrate downrange projectile detections at significant distances.
– Optimize signal processing for the operational on aircraft electromagnetic noise environment.
– Demonstrate cross-range bullet detection capability.
– Demonstrate projectile source location capability.
– Develop and demonstrate the performance of a man-portable HFI detection system.

	FY 2005	FY 2006	FY 2007
Speckle Exploitation for Enhanced Reconnaissance (SEER)	0.000	0.000	6.000

(U) The Speckle Exploitation for Enhanced Reconnaissance (SEER) program will develop a system to exploit the information carried in optical speckle. It will provide long-range non-cooperative identification of moving/stationary targets using the incoherent scattered laser speckle

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return of reflected active laser radiation. By ignoring optical phase, the system can be made much less complex with lower size, weight, power, and cost, and with reduced sensitivity to adverse turbulence-induced atmospheric distortion. 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 include target image, shape, size, detailed structural features, surface texture, reflectivity, polarization, macro and micro dynamics, 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 2010.

(U) Program Plans:
- Develop algorithms that reliably and uniquely associate target signatures with speckle patterns.
- Perform major system design trades.
- Implement algorithms using optical MEMs or other related technologies to achieve reduced size, weight and power.
- Design, develop, field, and test a prototype system on a tactical vehicle for transition to an operating command.

	FY 2005	FY 2006	FY 2007
Rescue Transponder	6.000	2.000	2.000

(U) Building upon technologies developed in other sensor programs, the Rescue Transponder (RT) program will investigate the use of covert localization and tracking technology to provide a very low probability of detection (LPD) call for help signal. The system is expected to 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 Rescue Transponder technology is planned for transition to the Joint Personnel Recovery Agency in FY 2007.

(U) Program Plans:
- Conducted successful field tests using prototype bench equipment.

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- Completed initial tag miniaturization effort.
- Fabricated, tested, and validated performance levels of tags.
- Develop tags which enable the user to be identified and localized by airborne or advantaged receivers.
- Design a custom digital and microwave integrated circuit to allow miniaturization.
- Build and test prototype tags, devices and transmitters and author viable manufacturing plans.
- Demonstrate the military utility of RT to transition partner.
- Conduct field experiments demonstrating first generation miniaturized tags.

	FY 2005	FY 2006	FY 2007
Low-Cost Cruise Missile Defense (LCCMD)	8.500	6.450	0.000

(U) The LCCMD program will design, develop, demonstrate and transition an affordable electronically scanned array (ESA) seeker for use on a missile interceptor system to defeat unsophisticated air vehicles. Unsophisticated air vehicles are affordable, can be procured in large numbers to overwhelm U.S. defenses and provide a credible long-term threat to both civilian population centers and military targets. To reduce the cost of defending against such threats, it is crucial to reduce the cost of the guidance and control sections of defensive weapons. The LCCMD program will enable this through analyses, laboratory testing and field-testing of an all-weather seeker costing less than fifty thousand dollars in production. The program has developed a novel active ESA concept using low cost single-chip transmit/receive module concept and is presently focused on the maturation and demonstrations. The LCCMD technology is planned for transition to the Army's Space and Missile Defense Command at the conclusion of Phase III, which is anticipated to be completed at the end of FY 2006.

(U) Program Plans:

- Built and tested active ESA antenna.
- Established Memorandum of Agreement transitioning active ESA to the U.S. Army partner for completing seeker integration, testing and performance analysis.
- Fabricated seeker back-end and integrated with ESA seeker antenna in preparation for ground or flight test.
- Conducted ground and flight testing.

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– Integrate seeker with U.S. Army demonstration interceptor.
– Conduct end-to-end system performance via captive carry flight testing.

	FY 2005	FY 2006	FY 2007
RF MEMS Improvement	6.977	0.550	0.000

(U) RF MEMS switches in the X, Ka, and Ku band hold great promise for DoD radar applications due to their inherent small size, light weight, low power consumption and low loss. The RF MEMS Improvement program will extend lifetimes, develop inexpensive packaging techniques, and enhance RF performance of RF MEMS switches to allow use in devices such as phase shifters, reconfigurable apertures, and tunable filters. The RFMIP 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.

(U) Program Plans:
– Developed process improvements, supported by predictive performance models, in competing MEMS fabrication and packaging techniques.
– Performed six design and testing iterations of packaged MEMS.
– Demonstrated ability to fabricate low-cost, low-loss, long life MEMS switches meeting DoD requirements.
– Demonstrated reliable accelerated lifetime tests for fast determination of switch reliability pursuant to further lowering the cost of such devices.
– Demonstrate fully integrated switch circuits (e.g., fully integrated phase shifters, switchable filters) with substantially better performance than discrete switch approaches.
– Demonstrate integration of RF MEMS switches together with integrated transistor circuits so as to realize compact, single-chip systems.

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	FY 2005	FY 2006	FY 2007
Digital Radio Frequency Tag (DRAFT)	1.375	0.000	0.000

(U) The Digital Radio Frequency Tag program developed a flexible, potentially low cost technology to allow radars Moving Target Indicator (MTI) and Synthetic Aperture Radar (SAR) to receive data from ground devices. This program developed a small, lightweight and affordable RF Tag for data exfiltration from unattended ground sensors and for communication with vehicles and personnel throughout the battlespace. This is particularly useful for the identification and location of coalition units. Other advanced tag capabilities were investigated and developed, adding additional communications capabilities to the tags for enhanced interoperability with combat identification and communications systems. These added capabilities give the tags dual-mode capability: to function as a tag when radar is present, or to function as a more conventional radio beacon device when radar is not available. Additionally, small-scale tag variations have been considered for other missions, including dismount and non-cooperative red-target tracking, with the net effect of substantially enhancing situational awareness and combat identification advantages for U.S. forces in conventional and unconventional ground operations. The DRAFT program transitioned to the Army and to the Marines in FY 2005.

(U) Program Plans:

- Completed 5 baseline radar tag prototype units.
- Completed design of advanced tag concepts.
- Conducted laboratory device testing and characterization.
- Conducted airborne field tests and user demonstration.
- Completed dual-mode tag communicator design.
- Demonstrated dual-mode tag communicating on SATCOM waveform.
- Developed dismount/red tag prototypes and conduct laboratory device testing and characterization.

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	FY 2005	FY 2006	FY 2007
Wireless Vibration Sensor Initiative	1.000	0.000	0.000

(U) Continued support of the development and qualification of open system architecture wireless sensor technology.

(U) <u>Other Program Funding Summary Cost:</u>

- Not Applicable.

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RDT&E, Defense-wide BA3 Advanced Technology Development	Sensor Technology PE 0603767E, Project SEN-02

COST (In Millions)	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Sensors and Exploitation Systems SEN-02	134.742	127.789	143.083	148.506	145.463	146.963	145.963

(U) Mission Description:

(U) The Sensors and Exploitation Systems project develops and demonstrates advanced sensor and exploitation technologies. These efforts, along with those in Project SEN-01 provide warriors 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. These needs are addressed by the following programs: Advanced Exploitation Systems Technology, Network Centric Sensing and Engagement, Advanced Optical Sensor Technology, and Advanced Radar Sensor Technology.

(U) Program Accomplishments/Planned Programs:

	FY 2005	FY 2006	FY 2007
Advanced Exploitation Systems Technology	42.098	40.182	42.463

(U) The Advanced Exploitation Systems Technology program develops semiautomatic methods to interpret and exploit sensor data. The objective is to detect and identify military threats. Data sources include national, theater and, organic surveillance and reconnaissance systems. Critical performance issues are timeliness, accuracy, error rates, and interpretation workload. The program addresses the challenges of target acquisition and tracking under restrictive rules of engagement. The technology applies advanced signal processing and machine vision to leverage advances in sensor capabilities. Initiatives in this program include the following:

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- The Frequency-Diverse Spatial/Spectral Sensor Exploitation initiative develops methods to better utilize advanced sensors. The initiative encompasses high-resolution multispectral, multipolarization, radio frequency, and electro-optical and active optical sensors. The program significantly improves mapping, terrain characterization, target detection, and situational awareness. The technology explores applications for both medium-and high-altitude deployment and permits fusion, automated exploitation, and visualization of products from diverse classes of sensors. These sensors and processing techniques enable commanders to enjoy wide-area detection, characterization, and geolocation information along with application to facilities, vehicle, and dismounted targets in both tactical situation awareness and strategic indication and warning. These tools support rapid mapping and terrain characterization support in near-real time for support of robotic and manned maneuver forces. Technologies are planned for transition to the National Geospatial-Intelligence Agency.

- The National/Tactical Exploitation (NTEX) initiative develops technologies to locate and identify enemy air defense and missile units. NTEX uses multi-source imagery and data from both National reconnaissance systems and tactical sensor assets. Under a DARPA Memorandum of Agreement with the National Geospatial-Intelligence Agency (NGA), the project places researchers in facilities with access to real data and analysts. These researchers submit their sensor exploitation developments for rapid assessment by operational analysts using real world data. NTEX builds upon technologies developed under the DARPA Semi-Automated Imagery Intelligence (IMINT) Processor Advanced Concept Technology Demonstration. The program demonstrates increased capability to model, detect, and locate air defense targets and surface threats, including those that have been denied, modified, or have yet to be modeled. The NTEX technology is planned for transition to the National Geospatial-Intelligence Agency at the conclusion of Phase III anticipated to be completed by FY 2006.

- The Video Verification and Identification (VIVID) initiative develops technology to automate moving target strike operations for remotely piloted aircrafts (RPAs). 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 permit reacquiring 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 technologies significantly advance 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 FY 2007.

- The Tactical Sensor Network Technologies (TSNT) initiative develops detection, tracking, identification, and pattern analysis capabilities that operate in all nodes (fixed or mobile) within a networked, distributed multi-sensor system. The processing to be performed at each network node depends on the sensors reporting to that node, the subscribing commanders, and resource management decisions. TSNT exploits locality of sensing, but will leverage the advantages of a self-forming adaptive network for signal processing. Algorithms are designed to be aware of the sensor network and adapt their processing algorithms based on self-discovered network topology. The algorithms also take into account power management constraints, communications bandwidth limitations, and constraints found in the local environment. TSNT is resilient to the failure of any node while maintaining sufficient consistency to support commanders' collaborative tactical planning. Technologies are planned to be transitioned to US Army (PEO IEWD).

- The Exploitation of 3-D Data (E3D) initiative develops techniques for rapidly exploiting 3-D sensor data. Such data is proliferating from growing numbers of advanced sensors, such as Laser Detection and Ranging (LADAR) and Laser Identification Detection and Ranging (LIDAR). Three dimensional data represents a rich resource for use in precision target identification. E3D demonstrates that the target identification performance of 3-D information greatly surpasses that of 2-D image-based methods. The program effort consists of three distinct processes: (1) Target Acquisition (TA) develops methods based on search of a local 3-D volume for detecting possible targets in scene; (2) Target Recognition (TR) investigates mathematical approaches to the identification of specific targets and target types detected by TA; and (3) Modeling explores methods of modeling the structure and variability into a representation exploitable by TR to identify targets. The resulting software tools are designed to be integrated into operational ground stations processing 3-D sensor data. The E3D technology is planned for transition to the SOCOM at the conclusion of Phase IV anticipated to be completed in FY 2006.

- The Dynamic Tactical Targeting (DTT) initiative 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 (TSTs). 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 enable multi-scale estimation of 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

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interest; and 4) processes and manages the voluminous data produced by various sensors in time to provide the warfighter information required to prosecute TSTs. The DTT technology is planned for transition to the Air Force by FY 2007.

- The All-Source Target Characterization initiative 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 target key features and other discriminates. The technology provides tools to process and disseminate target signatures to the field in usable formats for direct insertion into operational systems and 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.

- The Automatic Target Recognition Technology (ATR) initiative matures automation of target detection and analysis for multi-view multi-sensor data. This will enable the efficient identification of targets of interest, to the level of fingerprinting of those targets according to their unique characteristics. This capability will enable analysts to track vehicular targets, even though the views are taken at relatively infrequent intervals. It will also enable analysts to make full use of both novel national and increasingly abundant tactical data sources, including EO/IR, SAR, and multispectral data. Using robust target cueing and identification methods gleaned from advanced academic pattern recognition and object recognition theory, the project will develop recognition capabilities over large target classes within a computational form factor appropriate for insertion into a distributed architecture of sensor platforms. This effort will develop tools to permit rapid user interaction with imagery and processing results and provide real time feedback to operators indicating target decision confidence. The project will operate in conjunction with the National Geospatial-Intelligence Agency (NGA), and includes transition of capabilities to the production environment at NGA.

(U) Program Plans:

– Frequency-Diverse Spatial/Spectral Sensor Exploitation
  - -- Design, analyze, and assess new concepts for exploitation of advanced sensors: RF, EO/IR and active optical frequency-agile spatial/spectral/polarimetric.
  - -- Perform phenomenological investigations to assess target signature stability, variability and separability.
  - -- Develop prototype tools for exploiting signatures.
  - -- Design, develop, and evaluate brassboard sensor hardware.

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-- Evaluate system performance under controlled environments.
-- Design, develop, and evaluate form, fit, and function sensor hardware.
-- Integrate on the aircraft and evaluate performance in flight test over realistic targets and large clutter sets.

– National/Tactical Exploitation (NTEX)
-- Demonstrate the ability to recognize components of specific air defense and missile units using automated processing of national/tactical sensor data.
-- Demonstrate the ability to model targets observed from sensor views, then locate and identify those targets autonomously in subsequent imagery.
-- Demonstrate the ability to model denied and expedient targets from a few sensor views, then locate instances of those targets that would be overlooked by analysts in a real-world situations.

– Video Verification and Identification (VIVID)
-- Develop techniques to automate detection, classification, and tracking of enemy, mobile, surface targets in visible and infrared motion imagery acquired by remotely piloted aircraft (RPA).
-- Develop automated techniques to detect moving vehicles and dismounts in single or multiple fixed areas for ISR operations or final inspection of weapon strike areas.
-- Demonstrate integrated, semi-automated engagement of hostile surface targets with precision weapons guided by data from video sensors on airborne platforms.

– Tactical Sensor Network Technologies (TNST)
-- Develop algorithms for distributed situation assessment at all nodes of a networked group of sensors.
-- Integrate and assess distributed system performance in large-scale simulation and limited-scale testing.
-- Demonstrate robustness of TSNT networked sensing under network and environmental stresses.
-- Incorporate tracking, target identification, and target assignment algorithms for fully distributed operation.

– Exploitation of 3-D Data (E3D)
-- Provide additional synthetic data and collect advanced laser radar (LADAR) data for research and development modules.

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-- Acquire and refine 3-D models of potential target vehicles.
-- Develop tools to locate, classify, identify, and characterize the operational states of ground targets using data from 3-D sensors (e.g., LADAR) making use of structural models of candidate target geometries.
-- Proliferate structural models to encompass hundreds of candidate target types.
-- Expand capabilities to perform precision recognition in the presence of articulation and obscuration.
-- Improve performance of real-time processing.
-- Integrate E3D software into a fingerprinting system capable of identifying specific vehicle instances.
-- Extend model-based vision technologies to classify, identify, and characterize the operational state of ground targets from other sources of 3-D sensor data.

– Dynamic Tactical Targeting (DTT)
-- Demonstrate human interaction with closed-loop control of fusion and sensor management in a simulation environment.
-- Develop rapid 4D registration of multiple tracks to enable continuous tracking of numerous targets.
-- Develop information fusion methods and the capability to plan and replan appropriate sensor platforms; enable continuous track of multiple time-sensitive targets simultaneously.
-- Develop end-to-end robust system capability with integrated DTT components in the Air Force Research Laboratory testbed.
-- Develop system measures of performance for evaluations.
-- Integrate the system with an existing Air/Ground Battlespace Simulator/Testbed and perform experiments.
-- Complete a robust laboratory demonstration of the system.
-- Build a system to test in field demonstrations.

– All-Source Target Characterization
-- Obtain a large set of target vehicles of extreme variety.
-- Characterize the shape, surface material, equipment, and mobility characteristics.
-- Obtain data on all vehicles in a scripted scenario representative of future threat operations.
-- Release data for a baseline set of vehicles to develop target models.
-- Conduct quarterly characterization exercises given a fixed time to develop a new set of target models from observed data.

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-- Evaluate performance by comparing reconstructions with the shape, surface material, equipment, and mobility characteristics measured on the actual vehicles.

– Automatic Target Recognition Technology (ATR)
  - -- Develop problem sets from real data taken by tactical and national assets, and mature ATR algorithms to achieve 90% identification performance on realistic recognition problems.
  - -- Mature registration technology to facilitate multi-source recognition.
  - -- Develop algorithms to permit near real-time performance to enable ATR against larger and more generalized target sets to keep pace with data collection rates.
  - -- Employ advanced pattern recognition methods to enable fingerprinting of specific kinds of vehicular targets using multiple stand-off data sources.

	FY 2005	FY 2006	FY 2007
Network Centric Sensing and Engagement	28.144	38.683	39.605

(U) The Network Centric Sensing and Engagement Program develops technology and tools to support precise situational awareness, rapid targeting, and precision engagement through the exploitation of systems of networked sensors. 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 ground - based fixed and mobile 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. Initiatives in this program include the following:

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- The Camouflaged Long Endurance Nano-Sensors (CLENS) initiative develops low-cost, lightweight micro-sensors to detect, geolocate, track, and classify targets in difficult environments. The system leverages ultra-wideband radio technologies developed for advanced communications. The combination of active, coherent, distributed-network sensing offers unique capabilities not possible from stand-alone, single-point systems. CLENS enables reduced force protection and supports monitoring of borders and critical CONUS sites, and long-duration covert monitoring of target sites such as terrorist camps. CLENS has broad application in support of comprehensive intelligence, surveillance, and reconnaissance for situational awareness and enables persistent sensing of dismounted combatants in forested areas and other tough environments. The CLENS technology is planned for transition to the SOCOM at the conclusion of Phase III anticipated to be completed by FY 2007.

- The Tactical Targeting Network Technologies (TTNT) initiative develops rapidly reconfigurable, affordable, robust, interoperable, and evolvable communications technologies. Resulting technologies support airborne network-centric targeting. Goals for the TTNT tactical network are: (1) reconfigurability in fractions of a second; (2) wideband capacity (10+Mbit/s) on demand; (3) near zero (2 milliseconds) latency for high priority messages; (4) complete interoperability with Link 16; and (5) cost effectiveness. This program addresses technical issues including physical waveforms and frequency allocations, fast security subsystems, and distributed network management. It is developing novel digital processing techniques to eliminate the need for centralized network synchronization. TTNT is pursuing an omni-antenna-based approach with a self-adaptive, channel sensing, multiple user access protocol. It employs spread spectrum waveforms optimized for rapid carrier acquisition, featuring powerful turbo code error detection and correction. This physical layer provides well-integrated security architecture. The network architecture is designed to exploit commercial-off-the-shelf technology wherever possible. TTNT will incorporate Joint Tactical Radio System software defined radio standards. Performance in simulations and laboratory testing with bread-board equipment exceeds the current phase program goals. TTNT is designing and fabricating a full security architecture brass-board system. TTNT transition activities include developing Software Communications Architecture (SCA) compliant software, advanced power amplifier, wideband transceiver, and Low Probability of Intercept/Low Probability of Detection (LPI/LPD) modes so that TTNT is moderately low risk for incorporation into production programs. The TTNT technology is planned to transition to the Air Force, Army, Marine Corps, and Navy, and is anticipated to be completed in FY 2006.

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- The Quint Networking Technology (QNT) (formerly Rotorcraft SIGINT/COMINT Geolocation) is a modular, multi-band, network data link program focused on providing capabilities that close the seams between five nodes - aircraft, unmanned combat air vehicles (UCAV), 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 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 2008.

- The Federated Object-level Exploitation (FOX) initiative assembles the results of image analyzers, target recognizers, and signal processors into a collection (federation) of situation estimates and describes objects of interest ranging from terrain, roads, and surface type to militarily significant vehicles, buildings, and people. The estimates enable prediction of future observables, enabling differences between the predictions and the observations to trigger change detection and analysis that updates the estimates. The estimates are maintained, in a consistent manner at multiple sites, distinguished by different areas of interest, target sets, and data sources. Technologies are evaluated on real-world data at experimental facilities collocated with operational analysts, and transition takes place incrementally as individual technologies mature. FOX began in FY 2006 and transitions to Network-Centric Warfare Technology, PE 0603766E, Project NET-01 in FY 2007.

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- 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 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 cuing to engage insurgents, and deeper forensic analysis to identify their support structures. 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.

- The Target Geolocation from a UAV (GeoLoc) program uses novel photogrammetric techniques to provide accurate geolocation of ground targets (<10 meters CEP) from small and mid-size UAVs. This represents an order of magnitude improvement in accuracy compared to instrumentation used on high-end UAVs. Further it requires no new hardware on-board the aircraft and does not rely upon prepared reference imagery. This photogrammetric technology will permit UAVs to not only observe targets for the first time, but also to direct fire from coordinate-seeking weapons. Furthermore, the technology will be extended to provide real-time geolocation on moving vehicles as well, enabling engagement of moving targets without use of laser designators, and without any human operators in harms way. The thrusts and future capabilities of the GeoLock Program are: detection, precision identification, tracking, and destruction of elusive surface targets from networked manned and unmanned systems. Technologies are planned for transition to the U.S. Air Force.

- The Wide Area Video Exploitation project will develop technology to enable wide field-of-view visible and infrared imagery (EO/IR) 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 project 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 U.S. Army.

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(U) Program Plans:

- Camouflaged Long Endurance Nano-Sensors (CLENS)
  - Develop a breadboard ultra-wide band radar micro-sensor for dismount detection and tracking.
  - Design receiver nodes to process micro-sensor that detects into tracks and exfiltrates data.
  - Develop tracking algorithms to consolidate range-only detects into contact tracks.
  - Fabricate targeted form factor micro-sensors.
  - Conduct ground demo with one receiver/processor and many micro-sensors.

- Tactical Targeting Network Technologies (TTNT)
  - Complete brassboard design and fabrication.
  - Complete brassboard TTNT flight experiments and demonstrations at large scale.

- Quint Networking Technology (QNT) (formerly Rotorcraft SIGINT/COMINT Geolocation)
  - Conduct analysis, design and hardware-in-the-loop tests.
  - Build and evaluate brassboard in stage 1 tests.
  - Cycle and test brassboard Stage 2 tests and flight tests.

- Federated Object-level Exploitation (FOX)
  - Acquired real-time access to data from all-source national and tactical sensors operating over an area of interest.
  - Established connectivity at three testbed sites which the data was received.

- Persistent Operational Surface Surveillance and Engagement (POSSE)
  - Conduct a comprehensive analysis of existing surveillance assets in the Iraqi theatre.
  - Develop a systems architecture and asset utilization plan that maximizes persistent surveillance capability in high priority regions, based on currently available assets.
  - Identify coverage and gaps and required new capability needed to satisfy persistent surveillance and force protection objectives.
  - Define 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.

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- -- Initiate accelerated development of gap-filler sensors and/or platforms.
- -- Develop an integrated capability to exploit all theatre-deployed ISR assets in a coordinated, systematic manner.
- -- Test an initial POSSE exploitation system at the National Training Center.

– Target Geolocation from a UAV (GeoLoc)
- -- Evaluate platform noise models.
- -- Demonstrate reliable point feature extraction.
- -- Integrate with UAV telemetry.
- -- Demonstrate real-time geolocation from airborne video.
- -- Integrate and transition to Common Ground Station.
- -- Extend algorithms for geolocation of moving targets.
- -- Demonstrate real-time geolocation of moving targets.

– Wide Area Video Exploitation
- -- Evaluate imagery and algorithms to perform stabilization and multi-hypothesis tracking.
- -- Build video processing architecture to demonstrate an ability to track 50 or more moving entities in playback mode of 50 Megapixel video data with a frame rate of at least 1 Hz.
- -- Integrate computer architecture with a collection platform to provide tracking over hundreds of entities simultaneously in 100 Megapixel (or higher) video data.

	FY 2005	FY 2006	FY 2007
Advanced Optical Sensor Technology	26.519	27.869	42.015

(U) The Advanced Optical Sensor Technology Program significantly improves warfighter situation awareness, surveillance, reconnaissance and targeting. The program exploits advancements in electro-optic, hyper spectral imaging, optical polarimetry, and advanced three dimensional active optic sensing. Initiatives in this program include the following:

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- Standoff Precision ID in 3-D (SPI 3-D) is developing an affordable sensor package capable of high-resolution 3-D images for confirmatory target ID at long ranges (>10km). The SPI-3D sensor overcomes obscuration and penetrates foliage, camouflage, and cloud layers via range gating. The system provides intensity, range and polarization for each pixel in the field of view with each laser pulse – SPI-3D is the first laser radar with this capability. The program includes a series of ground and air vehicle demonstrations of SPI-3D precision ID capabilities and track fusion techniques. The objectives are to provide: (1) rapid acquisition; (2) polarization exploitation; (3) intensity mapping; and (4) high range resolution. Results will provide commanders with significantly improved identification of enemy ground targets, both stationary and moving. The SPI-3D sensor system employs existing commercial-off-the-shelf optics, focal plane arrays and gimbals, combined with a novel Pockels cell range measurement technique. The SPI-3D technology is planned for transition to the Air Force at the conclusion of Phase III, which is anticipated to be completed by FY 2008.

- The Synthetic Aperture Ladar for Tactical Imaging (SALTI) initiative will develop and demonstrate an airborne synthetic advanced laser radar (ladar) imager capable of producing high-resolution three-dimensional imagery at long ranges. The SALTI approach combines the long-range day/night access afforded by conventional synthetic aperture radar (SAR) with the interpretability of high-resolution optical imagery and the exploitability of three-dimensional (3-D) imagery, for fit and deployment within a tactical-sized package. 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. Development and demonstration of long range performance is scheduled to be conducted through FY 2008. The SALTI technology is planned for transition to the Air Force by 2009.

- The Video Exploitation for Precision Identification initiative explores new ways to overcome or circumvent the limitations of automatic recognition of targets (ATR) and monitoring fixed sites and facilities by exploiting the unique opportunities provided by persistent sensing, such as high temporal and spatial sampling rates, long-term observation, and perspective diversity. The project develops techniques specifically designed for exploitation of persistent and ubiquitous sensing over larger and larger areas of interest. The project includes basic research that addresses a broader and more robust view of target recognition, classification, and generalization. The thrusts and future capabilities of the PEPS Program are: detection, precision identification, tracking, and destruction of elusive surface targets. The capabilities will serve as a force multiplier for urban area operations. Technologies are planned for transition to the Air Force.

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- The Firesight Aerial Sensor Mapper (FSAM) program will develop an autonomous UAV-based sensor exploitation and decision support capability that provides dynamic situational awareness for large-scale firefights in urban environments. The FSAM concept will combine novel thermal and acoustic gunfire detection capabilities with a 4D (space-time) fusion approach within the framework of a probabilistic inferencing network to reliably locate and map the array of urban firing events with low spatial uncertainty and with low rate false alarms. This includes the distribution of shooters and weapon types as well as the firepower movements and trends associated with the dynamically changing battlefield situation. FSAM will enhance lethality and survivability of the friendly ground forces by dramatically increasing the speed, accuracy and completeness of detecting, identifying, tracking and destroying the elusive enemy in complex urban terrain, including the irregular combatants. Integrated with and within the emerging battle command systems, intel systems and unmanned/manned networks, FSAM will be a force multiplier in urban area operations. FSAM will be the first system to address battalion-level urban firefight detection and tracking, providing field commanders with a holistic, up-to-the-minute dynamic picture of the movements, evolution, and emerging firepower tactics of the enemy unit in the complicated urban battlespace. Further, the real-time picture provided by FSAM will not be a collection of pixels, but interpreted, computer-understandable formal descriptions of the evolving events and entities on the battlefield. As such, FSAM’s output will be a critical automated input to battle command and intelligence systems. Technologies are planned for transition to the U.S. Army (PM RUS).

- 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 develop new 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 will be able to observe, track, and laser designate the target as required, using a single device. This device will 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 will also survive in a harsh environment for long periods of time with minimal maintenance. The High Precision Long Range Designator/Locator technology is planned for transition to the Army and SOCOM by FY 2009.

- 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 means, convey the information to other units or systems connected to it.

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- The Advanced Optical Sensing (AOS) program will develop 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 will focus on bringing recent advances in photonic and other technologies to military airborne optical sensing systems. This effort will develop advanced digital signal processing to support onboard image reconstruction, atmospheric correction and system calibration. Techniques will be explored to realize a 1 meter class 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, will be 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 will seek to extend these technologies and make them practical for airborne surveillance systems.

- 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 precision tracking to enable engagement on a large number (~100) targets 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 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 at the conclusion the program anticipated in FY 2009.

- The SandBlaster program will develop a passive pilot enhancement system that fuses visible, 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,

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(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 USSOCOM and the Marine Corps in FY 2008.

- The Super-Resolution Vision System (SRVS) initiative 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 an atmospheric turbulence-generated micro-lensing phenomena to generate better than 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 develop advanced technologies to enable atmospheric, turbulence-induced, super resolution, and will culminate in a field demonstration of a prototype. Technology developed under this program will transition to the Services in 2010.

(U) Program Plans:

– Standoff Precision ID in 3-D (SPI-3D)
  - -- Developed and tested brassboard of complete imaging system, including laser and Pockels cell elements.
  - -- Determined accuracy and precision of ranging technique.
  - -- Conducted long range ground tests from mountaintop test site.
  - -- Developed flight engineered system and conducted preliminary test flights.
  - -- Integrate and demonstrate system from manned aircraft against stationary and moving targets.
  - -- Conduct series of confirmatory tests to demonstrate utility of the SPI-3D sensor system under a wide range of environments and target conditions.
  - -- Transition SPI-3D sensor technologies and system concept to Services.

– Synthetic Aperture Ladar for Tactical Imaging (SALTI)
  - -- Complete sensor packaging and ground testing.
  - -- Refine image formation processing algorithms to coherently combine multiple laser pulse returns and to compensate for platform motion during the collection of these multiple pulses.

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-- Complete Early Flight Tests, which will produce the first-ever Synthetic Aperture Ladar high-resolution 2D and 3D image images from aircraft.
-- Characterize coherent infrared propagation through the atmosphere under operational conditions, to assess the feasibility of long range operation.
-- Develop lasers for higher power and higher bandwidths to support Long Range Demonstration (LRD).
-- Demonstrate, in LRD, SALTI performance at operationally significant ranges on contractor-owned airborne testbed.

– Video Exploitation for Precision Identification
-- Instrument an overseas military facility with a dense set of still and video sensors.
-- Regularly insert instrumented vehicles and soldiers into the ambient traffic and activities.
-- Select a broad set of relevant technologies and implement as software prototypes.
-- Evaluate prototypes based on their ability to reconstruct aspects of the instrumented vehicles and soldiers.
-- Select prototypes for integration into a real-time testbed.
-- Design, build, and operate a video exploitation testbed, providing regular feedback to technology developers.
-- Transition technologies to relevant acquisition programs for target identification, site characterization, and force protection.

– Firesight Aerial Sensor Mapper (FSAM)
-- Develop and demonstrate the feasibility of detecting multiple simultaneous shooters (AK-47, mortars, RPG) in obstructed urban terrain using video IR imaging and processing combined with urban-capable acoustic sensor data operating in conditions comparable to UAV-based sensors, at Yuma Proving Grounds.
-- Develop and demonstrate fusion algorithms capable of integrating the acoustic and video IR sensor data with 3D urban terrain information and prior-time information into a time-dependent 3D map of individual and aggregated red force actions.
-- Design and evaluate a brassboard FSAM integrated hardware/software system.
-- Design and evaluate a form-fit and function FSAM hardware system for UAV installation and conduct end-to-end system performance tests that include all aircraft effects under static and dynamic conditions.
-- Conduct airborne flight-testing and demonstrate performance with the fully integrated FSAM / UAV / Battle Command system.
-- Perform user evaluations in order to develop the system CONOPS and to demonstrate FSAM's capabilities to the warfighter community.

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– High Precision Long Range Designator/Locator (HPLD)
  - -- Build and demonstrate target-in-the-loop adaptive optics ability to achieve high resolution laser pointing and imaging of small targets.
  - -- Validate the pointing accuracy of eye safe integrated optics at targets multiple kilometers away.
  - -- Design, build, and demonstrate an integrated HPLD system of low weight and volume that validates the ability to be deployed and erected by dismounted troops.

– Omni-Directional Flash & Launch Detection, Positioning, Classification and Observation System (MEGA)
  - -- Develop and demonstrate IR sensor prototype.
  - -- Develop and demonstrate stationary omni system.
  - -- Develop and demonstrate mobile platform omni system.
  - -- Integrate mobile system with vehicle and demonstrate in series of field tests.

– Advance Optical Sensing
  - -- Investigate approaches for producing large aperture imaging systems with constrained size.
  - -- Explore uses of adaptive optics to provide optical corrections for multiple sub-apertures.
  - -- 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.
  - -- Design, build and demonstrate next generation airborne surveillance system.
  - -- Incorporate state-of-the-art automatic target recognition capabilities into system.
  - -- Transition system to services for production and fielding.

– Large Area Coverage Search-while-Track and Engage (LACOSTE)
  - -- Develop objective system concepts enabling wide-area stand-off sensor for urban tactical-grade Ground Moving Target Indication (GMTI) tracking.
  - -- Develop electroptical infrared electronically scanned sensor components.
  - -- Develop optical GMTI tracking algorithms.
  - -- Lab test the sensor parameters against measured urban data.

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-- Manufacture and integrate the LACOSTE sensor components.
-- Rooftop demonstration of large cone-angle electronically scanned urban GMTI.

– SandBlaster
-- Test attenuation properties of dust on passive millimeter wave imaging and develop system requirements.
-- Develop and identify the millimeter wave camera and related situational awareness technologies.
-- Integrate the system and demonstrate capabilities.

– Super-Resolution Vision System (SRVS)
-- Investigate optimal control algorithms and implementation using optical MEMs and chip-based technologies.
-- Perform system design.
-- Design and develop a brassboard prototype for laboratory and field experimentation and developmental testing.
-- Integration into a prototype soldier-portable optical system.

	FY 2005	FY 2006	FY 2007
Advanced Radar Sensor Technology	32.081	21.055	19.000

(U) The Advanced Radar Sensor Technology program promises significant improvements in military sensor performance in situation awareness, surveillance, reconnaissance and targeting applications. Its emphasis is on surface targets and threats. Program efforts are focused 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 (GMTI) 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. Initiatives in this program include the following:

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- The Wide Area All Terrain Change Indication and Tomography (WATCH-IT) initiative developed real-time VHF/UHF synthetic aperture radar (SAR) automatic change detection and target discrimination technologies. WATCH-IT provides the commander with rapid, robust detection of threat systems in the open, under camouflage, and in foliage. The program features discrimination algorithms that examine change detections to determine if they have threat vehicle characteristics. Indications of change cue on- or off-board high-resolution sensors to perform target identification. WATCH-IT is designed to operate from platforms, such as high altitude unmanned air vehicles (UAVs). The technology will demonstrate high area-coverage rates with few false alarms. WATCH-IT provides commanders with a critical capability that currently does not exist. The program also developed techniques to extract 3-D vehicle images from multiple-pass polarimetric SAR imagery. This capability enables rejection of confusers (i.e., decoys, relocated vehicles that are not of military significance), thus greatly improves target classification/identification. DARPA established an MOA with the National Geospatial – Intelligence Agency for this program in September 2004. The WATCH-IT technology transitioned to the NGA at the conclusion of Phase II in 2005.

- The Knowledge Aided Sensor Signal Processing and Expert Reasoning (KASSPER) initiative radically altered the fundamental "front-end" signal processing architectures of advanced military sensors. It accomplished this through the real-time integration of a dynamic environmental knowledge database. Real-time "environmental awareness," absent in conventional systems, dramatically improves clutter and interference rejection and significantly enhances sensor products. Current radio frequency sensors with adaptive signal processing estimate the background interference using sample statistical estimation. Key technologies included advanced algorithms and high-performance computing architectures capable of memory-intensive adaptive signal processing. The KASSPER technology transitioned to the Air Force during FY 2005.

- The Augmented Aerial Sentry (AAS) program will develop a rapidly-deployable airborne system to provide assured protection of permanent or temporary U.S. base camps in hostile territory. AAS will include 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 can 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.

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- The goal of the Bipedal Detection project is to develop technology for the detection of humans walking (or running) using Ground Moving Target Indication (GMTI) radar hosted aboard a moving platform. Design criteria for the optimal radar system and operations concepts will be developed as part of the signal processing algorithm development. Multiple platforms will be required for system performance to show general bipedal motion detection over wide areas. 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. Technologies are planned for transition to the US Army.

- The Generation After Next Airborne Surveillance Radar (GAN) initiative evaluated new concepts for wide area coverage airborne ground surveillance radar technology by exploiting wide-beam staring systems rather than narrow-beam scanning systems. The approach studied challenges associated with low revisit rates, limited concurrency of modes, low power efficiency, low resolution, and sensor management.

- The Tethered Ultra-Long baseline Sparse Aperture (TULSA) initiative studied developing new means of exploiting single-ship airborne long-baseline sparse apertures. The initiative investigated techniques for deploying, calibrating, powering, feeding and processing received signals from active end bodies deployed on long, towed tethers, and signal processing to support use of single-aircraft, towed long-baseline sparse arrays for: (1) emitter geolocation and (2) long baseline multi-static radar applications, such as GMTI multi-lateration.

- The Networked Detection and Ranging (NetDAR) initiative is addressing an impending bandwidth crisis in radar. Commercial pressures on bandwidth usage will make it difficult for military radar systems to operate in peace time without interfering with or being interfered by other transmission sources. This initiative will explore technologies to turn this bandwidth crisis into an asset. By using signals of opportunity across the spectrum, systems will be developed that can passively exploit a multi-static and only transmit to augment the RF propagation environment. Multi-Input Multi-Output (MIMO) radar concepts will be developed that coherently integrate multiple signals to efficiently use the entire RF spectrum. This now makes all RF sources assets instead of interference sources. This will include adaptive waveform diversity and extending MIMO radar into airborne sources as a revolutionary approach to conventional multi-static radar. This program has evolved into the Visibuilding program in PE 0603767E, Project SEN-01.

(U) Program Plans:
- Wide Area All Terrain Change Indication and Tomography (WATCH-IT)

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-- Collected data using low-frequency, high-resolution polarimetric SARs.
-- Quantified the robustness of wide area change detection to factors, such as aircraft heading, depression angle, database aging, topography and terrain cover.
-- Assessed alternative change detection algorithms to determine the robustness to data variations, the computational requirements, and other factors impacting suitability for implementing WATCH-IT on an UAV.
-- Quantified the probability of detection and false alarm rate for a range of operating conditions.
-- Investigated methods to generate synthetic target signatures using software models or scaled frequency measurements.
-- Demonstrated WATCH-IT using the Foliage Penetration (FOPEN) SAR Advance Technology Development (ATD) system.
-- Demonstrated real-time, on-board change detection and high-speed discrimination processing in the ground station.

– Knowledge Aided Sensor Signal Processing and Expert Reasoning (KASSPER)
-- Developed advanced expert-reasoning algorithms using real and simulated data sets in non-real-time (offline) and real-time modes.
-- Developed real-time, high-dimensionality KASSPER software.
-- Conducted off-line KASSPER Constant False Alarm Rate & Radar (CFAR) demonstration.
-- Defined high performance embedded computing architecture to enable rapid memory access; design, build, test, and demonstrate.
-- Demonstrated KASSPER performance gains in real-time processing environment using real data sets.

– Augmented Aerial Sentry
-- Develop system architecture that will utilize existing and newly-developed sensing technologies to track potential and imminent threats.
-- Demonstrate effectiveness of system architecture.
-- Develop, demonstrate, and test system that incorporates multiple sensing technologies to provide situational awareness to commanders.

– Bipedal Detection
-- Conduct laboratory and airborne data collections using Ground Moving Target Indication (GMTI) radars and ground-level movements of dismount soldiers.

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- -- Develop algorithms to extract and classify human walking, running, and other repetitive activities based on collected data.
- -- Develop design concepts and perform a review of the algorithms, radars, and system concept for detection, tracking, and disambiguation of multiple humans performing repetitive bipedal activities.
- -- Field a prototype system and demonstrate an ability to monitor a wide area and detect and track up to a hundred dismounts simultaneously.

– Generation After Next Airborne Surveillance Radar (GAN)
- -- Developed missions and concepts of operation to evaluate GAN sensor concepts.
- -- Outlined basic functional requirements to support proposed missions and concepts of operation.
- -- Developed strawman concepts for GAN and evaluated their ability to satisfy the specified functional requirements.
- -- Developed a roadmap outlining an objective GAN system and an investment strategy.

– Tethered Ultra-Long baseline Sparse Aperture (TULSA)
- -- Developed a multi-sensor localization concept.
- -- Developed and evaluated relative navigation concepts to achieve desired geolocation accuracy.

– Networked Detection and Ranging (NetDAR)
- -- Develop hybrid passive/active radar system concept.
- -- Quantify performance benefits of multi-input multi-output exploitation of full RF spectrum.
- -- Design, build, test, and demonstrate multi-sensor integration experiment.
- -- Demonstrate performance gains in real-time.

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	FY 2005	FY 2006	FY 2007
360 Degree Portable Surveillance and ReConn Unit	2.400	0.000	0.000

(U) The 360 Degree Portable Surveillance and ReConn Unit project designed and fabricated an extremely large format video camera suitable for airborne reconnaissance by military forces in Iraq and elsewhere. The goal was to produce a 400-megapixel video camera – the world's largest. With suitable optics, such a camera will support the tracking of individual vehicles throughout a 10-km x 10-km area, or to enable moving target detection in a similar sized area.

(U) Program Plans:
- Created 48 M-pixel MegaSkyCam from modular components (digital focal panes, GPS and data links).
- Integrated eight MegaSkyCams to create the end device.
- Demonstrated detection and tracking algorithms on an array of processors to produce automated alerts.

	FY 2005	FY 2006	FY 2007
Sandia Intelligent Systems & Robotics Center	3.500	0.000	0.000

(U) Selected and funded research projects at the Sandia Intelligent Systems & Robotics Center.

(U) <u>Other Program Funding Summary Cost:</u>

- Not Applicable.