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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, R-1 #46

COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	199.445	177.598	182.225	203.424	229.482	254.396	276.896	Continuing	Continuing
Guidance Technology SGT-01	32.868	19.866	22.173	22.199	32.964	33.514	36.564	Continuing	Continuing
Aerospace Surveillance Technology SGT-02	60.204	40.722	61.545	78.838	88.232	90.550	109.300	Continuing	Continuing
Air Defense Initiative SGT-03	24.430	38.141	24.301	19.667	30.000	37.750	38.200	Continuing	Continuing
Sensors and Exploitation Systems SGT-04	81.943	78.869	74.206	82.720	78.286	92.582	92.832	Continuing	Continuing

(U) Mission Description:

(U) The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project is leveraging geolocation technologies to enhance the navigation and/or guidance packages of airborne platforms, ground vehicles and weapons. These improved systems will improve the accuracy and effectiveness of stand-off weapons, minimizing collateral damage while reducing the cost-per-kill.

(U) Aerospace Surveillance Technology programs are developing technologies to improve the accuracy and timeliness of surveillance systems in all weather, in hostile reception environments, and when necessary, in a covert manner. The programs funded by this project exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, high performance computing and low cost micro-electronics technologies.

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(U) The Air Defense Initiative is an on-going project whose overall goal is to reduce the proliferating cruise missile threat and enhance the survivability of US assets in the face of enemy electronic countermeasures.

(U) The objective of the Sensors and Exploitation Systems project is to provide the warrior with situational awareness and battlefield dominance by developing key sensor technologies; provide near-real-time semi-automatic exploitation of wide-area moderate resolution imagery data; provide real-time and accurate battlefield assessment and semi-automated precise and reliable target recognition and targeting of critical moving targets.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	209.971	232.319	211.893
Current Budget	199.445	177.598	182.225

(U) Change Summary Explanation:

FY 1999 Decrease due to SBIR and Omnibus reprogrammings, rescission (Section 8058), and minor repricing.
FY 2000 Decrease reflects Congressional adjustments, government-wide rescission and inflation reductions.
FY 2001 Decrease reflects reduction in scope of the Organic Ground Moving Target Indication program and rephasing of the Low Cost Cruise Missile Defense and Discoverer II efforts. The SAR ECCM program completion was accelerated to FY 2000 vice FY 2001 as previously planned. Other reductions are due to inflation adjustments and the minor repricing of ongoing programs.

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Guidance Technology SGT-01	32.868	19.866	22.173	22.199	32.964	33.514	36.564	Continuing	Continuing

(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. The achievement of these characteristics in an integrated system is the goal of this program. The Global Positioning System (GPS) Guidance Package (GGP) technologies funded in this project are applicable for both new or retrofit guidance/navigation packages for a variety of airborne platforms, ground vehicles, surface-to-surface standoff weapons and air-to-surface weapons. Additional thrusts are also included in this project to increase the ability of GPS users to operate effectively in presence of enemy jamming; to increase the versatility of navigation systems applications by developing micro-electromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation (Advanced Tactical Targeting Technology Program).

(U) GGP tightly integrates a miniature GPS receiver and an all solid state, low cost, navigation-grade, interferometric fiber optic gyroscope (IFOG) based miniature inertial measurement unit (MIMU) with an advanced navigation computer into a low cost ($15,000), precision navigation system. GGP Phase I addressed the technology issues involved in: (1) miniaturizing navigation grade inertial measurement units (IMUs) into a compact, manufacturable configuration; and (2) developing a multi-channel-on-chip, high dynamics GPS receiver. A Memorandum of Agreement (MOA) has been signed and implemented to demonstrate a Phase 1 unit on an Army Fire Support Team Vehicle (FIST-V). Successful demonstrations were conducted at Redstone Arsenal in June 1995 using a M981 FIST-V. Successful demonstrations also were conducted on an F/A-18. These tests assessed the performance of tightly coupled systems in high dynamics and validated Phase 1 design scenarios. GGP Phase 2 requirements place more stressing demands on performance of MIMU components and call for further reductions in size, power and weight. The Phase 2 was structured and continues as a competitive program with two prime contractors.

(U) The GGP program also will increase the ability of GPS users to operate effectively in the presence of enemy jamming or countermeasures (Global Positioning Experiments – GPX). It will demonstrate feasibility of airborne pseudolite (APL) concepts, which would sustain the availability

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of GPS signals to users in the presence of enemy jamming. The considerably increased transmit power of the APL fights off the effects of jamming on DoD receivers. APLs can be rapidly deployed on unmanned aerial vehicles (or other airborne platforms) and provide theater-wide coverage for individual soldiers, combat platforms and precision GPS-guided shoot-to-coordinate weapons. The project assesses three key challenges. First, it will demonstrate non-Keplerian orbit predictions of the APL and show that only software modifications are needed for GPS user receivers. Second, the APL must also accurately navigate using GPS satellites in the presence of jamming. Accordingly, this project provides for the design, development and demonstration of a low cost, space-time adaptive beamforming anti-jam receive antenna and a digital adaptive beamformer. With advanced algorithms, this will support greater than 45 dB nulls against up to six different jammers. Third, it is necessary to control the desired area coverage of APL transmissions. This will require demonstration of an advanced beam shaping transmitter antenna, precise management of the radiated power and the associated command and control structure.

(U) The Microelectromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, light weight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 will perform the following: (1) design and develop higher performance MEMS inertial gyroscope and accelerometer sensors, (2) select and refine foundries/foundry processes, (3) design the mechanical subsystem, and (4) select/refine the navigation software and perform INS simulations of the modeled sensors. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field. Three prime contractors are proceeding in Phase 2.

(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD). Today's threat radar targeting systems employed for SEAD fail to provide the rapid and accurate emitter geolocation needed to replace dedicated anti-radiation missiles (ARM) with generic, shoot-to-coordinate, smart weapons (e.g., JDAM or JSOW). The targeting system must negate emitter shutdown tactics now employed to defeat ARM guidance and enable simplified ordnance inventories. Generation and distribution of near real-time (e.g., seconds) comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any extra, SEAD dedicated, emitter collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combatant aircraft. AT3 will integrate in real-time the distributed multi-platform emitter collections using existing or planned tactical radios with advanced network management and signal processing. Additionally, to achieve the necessary wide deployment, AT3 self-contained collection packages must impose negligible burden on their airborne hosts and be available at affordable prices. Enabling technologies now in development at DARPA will be used, including highly agile digital

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receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS packages and advanced highly dynamic data fusion network management capabilities. Critical system advancements are (1) generating the commonly registered, theater-wide absolute doppler corrections to collected data and (2) managing the extraordinarily dynamic real-time data network including individual user kinematics and a changing aggregate participating user population.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- GPS Guidance Package (GGP). ($ 12.905 Million)
  - Maintained a second source for the GGP, thereby continuing as a competitive program.
  - Performed final integration and testing of GGP units.
  - Proceeded with adaptive signal processing/beamformer to null jammers.
  - Evaluated ranging accuracy of airborne GPS pseudolites.

- Microelectromechanical Sensor Inertial Navigation System (MEMS INS). ($ 8.292 Million)
  - Iterated MEMS foundry inertial sensor fabrication and initiated preliminary sensor testing.

- Advanced Tactical Targeting Technology. ($ 11.671 Million)
  - Completed AT3 preliminary design and system simulation.

(U) FY 2000 Plans:

- GPS Guidance Package (GGP). ($ 3.978 Million)
  - Complete evaluation of the feasibility of pseudolites; continue and complete adaptive signal processing and digital beamformer.

- Microelectromechanical Sensor Inertial Navigation System (MEMS INS). ($ 7.745 Million)
  - Begin MEMS INS integration with navigation software to demonstrate INS operation.

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- Advanced Tactical Targeting Technology. ($ 8.143 Million)
  - Complete Advanced Tactical Targeting critical design and begin fabrication.

(U) FY 2001 Plans:

- GPX. ($ 3.970 Million)
  - Complete development and evaluation of elements of the pseudolite network.
  - Initiate integrated demonstration.
- MEMS INS. ($ 5.955 Million)
  - Complete demonstration of MEMS INS operation.
- Advanced Tactical Targeting Technology. ($ 12.248 Million)
  - Complete fabrication and ground tests.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Apr 00	Complete AT3 critical component demonstrations and begin brassboard fabrication.
Aug 00	Deliver GPS Guidance Package (GGP) units to the Government.
Oct 00	Deliver GGP units to the Government (second source).
Oct 00	Complete laboratory test of digital adaptive beamformer.
Jun 01	Complete evaluation of pseudolite elements.

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Sep 01	Complete AT3 ground tests.
Feb 02	Complete demonstration of MEMS INS operations.

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aerospace Surveillance Technology SGT-02	60.204	40.722	61.545	78.838	88.232	90.550	109.300	Continuing	Continuing

(U) Mission Description:

(U) This project funds space and airborne 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, large constellation satellite architectures, low-power high-performance computing, and low-cost micro-electronics to develop advanced surveillance and targeting systems. Surveillance is not an end to itself but rather an enabler for force protection and precision strike. Therefore a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The Millimeter Wave Targeting & Imaging System (MMWTIS) program will develop and demonstrate the targeting and imaging technologies to enable a low-cost, all weather, day/night precision targeting approach against moving or stationary targets at millimeter wave (W band) frequencies. The technologies investigated will include active and passive techniques to achieve high resolution targeting (low circular error probability (CEP)) and imaging (1-3 m). An objective system could be used for weapons targeting, high-resolution imagery, and battle damage assessment. This program will pursue advanced radar algorithms and sparse aperture concepts, and intelligent incorporation of miniaturized monolithic integrated circuit (MMIC), advanced W band power amplifier technology, radio frequency photonics technology and low power high performance computing.

(U) The DARPA Digital Radio Frequency Tags program will develop a flexible, potentially low cost technology to allow radars (Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR)) to receive data from ground devices. This program will develop a small, lightweight and affordable RF tag for data exfiltration from unattended ground sensors and communication with vehicles and personnel throughout the battlespace. This is particularly useful for the identification and location of coalition units. Additionally, the Digital RF Tag architecture can be exploited for other missions, with the net effect of substantially enhancing US situational awareness advantages.

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(U) The goal of the Adaptive Spectral Reconnaissance Program (ASRP) is to build the technical underpinnings for future multispectral and hyperspectral systems to counter camouflaged and concealed surface targets. The program is a jointly funded DARPA/Army (CECOM) effort. ASRP will develop the technologies for real-time detection of tactical targets employing concealment, camouflage, and deception (CC&D) using hyperspectral sensor data to cue high resolution, geo-located, target imagery. DARPA will develop algorithms, models, and phenomenology databases for use primarily in the visible through near infrared (VNIR) and short wave infrared (SWIR) bands to provide daytime capability, while the Army will focus on development of advanced long wave infrared (LWIR) sensor technology that will eventually enable nighttime capability. ASRP will employ an airborne testbed to validate the technology elements being developed and the overall technical concept of a real-time hyperspectral technology-based tactical directed area search capability. ASRP will leave behind validated performance prediction tools, specifications for validated robust low false alarm rate target detection algorithms, a real-time processor system, validated target detection in the VNIR/SWIR, and a database of targets and backgrounds.

(U) The Discoverer II program is a DARPA, Air Force and National Reconnaissance Office (NRO) joint initiative to develop and demonstrate an affordable space-based radar (SBR) with Ground Moving Target Indication (GMTI) and Synthetic Aperture Radar (SAR) imaging capabilities that will revolutionize reconnaissance, surveillance and precision geolocation support to the tactical warfighter. Discoverer II is the direct descendant of the DARPA STARLITE initiative. In January 1998, the Defense Science Board (DSB) Task Force on Satellite Reconnaissance issued its report. The Task Force recommended that a modified STARLITE program be initiated, as a "Military Space Radar Surveillance Program," in an effort to achieve broad-area, all-weather, near-continuous radar access that could be integrated with military operations. Two central findings of the Task Force were that an on-orbit demonstration would likely be needed; and that a technical risk reduction program should be undertaken in advance of the demonstration to bring leading edge, higher risk technologies to bear to both meet warfighter needs at lower cost, and to enhance system maturity thereby facilitating a more direct and rapid transition to a follow-on operational system.

(U) Discoverer II is a staged technology R&D demonstration program. In the first phase industry will conduct detailed trade studies necessary to define both an affordable objective space-based radar system for the 2010 timeframe and a demonstrator system for the 2005 timeframe that shows that it addresses the highest risk of the proposed objective capability. Concurrent with the performance of trade studies by Discoverer II system integration contractors, results of the risk reduction efforts will be exploited to ensure Discoverer II R&D demonstration can be pursued with acceptable risk. Specifically, the technologies to be pursued include: 1) developing a low-cost, multi-mode GMTI/SAR space-qualified electronically scanned antenna, 2) developing low power Microelectromechanical Systems (MEMS) for scanning radar modules (10x reduced power requirement), and 3) sparse band processing for data compression allowing on-ground processing with moderate rate communications links, and Automatic Target Recognition (ATR) quality range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar

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(IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and precision guided munitions (PGM) targeting (precision geolocation accuracy theater wide). If industry trade studies, informed by the results of the Discoverer II risk reduction initiatives, show an affordable objective system is achievable, Phase II will build and fly two GMTI/SAR technology demonstration satellites. The R&D demonstration will validate the technical feasibility of advanced C4ISR capability complementing/extending current Unmanned Air Vehicle (UAV)/Aircraft architectures. The demonstration will show how an objective system can provide deep-look access to denied area, and near continuous coverage from diverse look angles over the battlefield. Objectives for the demonstration include mobile target detection, tracking, and targeting; intelligence preparation of the battlefield; wide area search and precision engagement with direct downlink to the warfighter. The Discoverer II demonstration program will allow the joint community to make an informed decision on future operational Space Based Radar after the FY 2005 flight demonstration.

(U) The Novel Antennas Program is developing novel techniques to produce small, lightweight systems with low power requirements that are capable of locating specific emitters in a dense interference environment. The program will leverage major investments already made in photonics, antennas and space-time adaptive array processing with the latest advances in digital receivers, signal processors, and devices employing superconductivity. Both centralized and distributed sensor/array architectures are being explored. Prior to FY 1999 the program funding was distributed amongst the component technology development programs. During FY1999, the distributed architecture was refined to include spectrum supremacy, the ability to deliver novel radio frequency (RF) capabilities to organic ground combat vehicles (e.g. Abrams tanks, HMMWVs).

(U) Underground Facilities (UGFs) are being increasingly employed to hide a variety of strategic functions, including command and control and weapons of mass destruction associated activities. The Counter-Underground Facilities program (CUGF) will develop technologies to characterize UGFs: identification of facility function, UGF pace of activity, pre-attack status of the facility, trans-attack activities, and post-attack status. Techniques will be developed to determine locations of critical systems (power, water, airflow vents), orientation and depth of structure, and pre-strike and post-strike changes in the substructure resulting from attack. Additionally, techniques will be developed for effluent detection and monitoring. Candidate technologies include, but are not limited to, low frequency electromagnetics, multi/hyperspectral imaging, seismic imaging, and coherent passive seismic, acoustic and electromagnetic monitoring.

(U) Non-Linear Radar Communications Mapper (NLRCM): High valued camouflaged targets usually have radio transceivers for command and control purposes. To avoid detection, an attempt is frequently made to operate these radios primarily in the receive mode and to minimize radio transmission. Exploiting nonlinearities in the radio receiver, it may be possible to design a radar to detect and locate these radios while they are in the receive mode or possibly while they are in a standby mode. It has been postulated that if a radio receives a high powered tone, due to

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nonlinearities in the receiver, it will reradiate an intermod of the received frequency and the frequency to which it is tuned. Alternatively, if two tones are received, the radio will transmit an intermod of the two received frequencies. The radar systems concept is to develop either an airborne or satellite pulse Continuous Wave (CW) radar to detect, locate and map the locations of radio equipment based upon their nonlinear intermod behavior. This program will exploit legacy communications technology developed under the Novel Antennas program into various application domains.

(U) The Large Millimeter Wave Telescope (LMT) program will develop the largest (50 meter aperture) fully steerable millimeter wave radio telescope built to date. The design features a sophisticated laser metrology system to maintain precise alignment of the optics, and real time closed loop adaptive control actuator system to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) Program Accomplishments and Plans:

(U) FY1999 Accomplishments:

- Millimeter Wave Targeting & Imaging System (MMWTIS). ($ 1.790 Million)
  - Completed concept development studies.

- Radio Frequency (RF) Tags. ($ 7.539 Million)
  - Completed development and testing of ID-only RF Tags for use with Synthetic Aperture Radar (SAR) and Moving Target Indicator (MTI) airborne radar platforms.
  - Continued design of data encoding and extraction algorithms for tags. Conduct design trades for miniaturizing the tags.
  - Initiated digital tag development.

- Adaptive Spectral Reconnaissance. ($ 5.630 Million)
  - Initiated development of end-to-end spectral model to include real/synthetic imagery generation, atmospheric/path radiance components, and sensor models, platform dynamics and algorithm segments.
  - Conducted joint data collects in Southeastern US (Eglin AFB) and Southwestern US (National Training Center, Yuma Proving Grounds, and at Nellis AFB as part of JEFX 99 exercise).
  - Achieved airborne real-time cued target detection using VNIR/SWIR hyperspectral sensor.

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- Continued data analysis and creation of spectral target and background signature database.
- Continued algorithm development, including implementation of fusion methodologies to reduce false alarms.
- Awarded contract for development of compact high sensitivity long wave infrared (LWIR) hyperspectral sensor with high resolution imager.

- Discoverer II. ($ 31.476 Million)
  - Supported jointly funded effort to conduct design trades and analyses leading to the candidate objective system and demonstration system designs by awarding three system integration (SI) contracts in Feb 1999. Core activities focused on cost/performance trades and completion of an Integrated Master Plan/Schedule. The initial Interim Evaluation Review was conducted in 4th quarter FY 1999.
  - Supported jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing, and exploitation software. Completed Thinned Transmit/Receive (T/R) Module Electronically Scanned Array (ESA) design.
  - Conducted mission utility analyses and concept of operations studies.

- Novel Antennas. ($ 12.269 Million)
  - Pursued data collection, and demonstrated algorithm performance against emitters in a realistic interference environment (urban, desert and hilly deciduous forest). Urban and non-urban environments were explored. Distributed architectures were developed and assessed, supporting hardware developed and demonstrated, and algorithm performance was evaluated.
  - The integrated system design was developed.
  - Conducted an experiment to determine the utility/synergy of close access, distributed collection capability into a distributed architecture.
  - Employed networked sensors, which leverage software reprogrammable radio technology to assess the utility of distributed architectures.

- Large Millimeter Wave Telescope (LMT). ($ 1.500 Million)
  - Completed preliminary critical system design.
  - Completed site characteristic measurements through seismic and wind monitoring.

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(U) FY 2000 Plans:

- Radio Frequency (RF) Tags. ($ 6.349 Million)
  - Conduct a Preliminary Design Review (PDR) for a digital RF Tag, system level trade study, and technology insertion plan; continue development of data encoding and extraction algorithms.

- Adaptive Spectral Reconnaissance. ($ 3.978 Million)
  - Complete algorithm development, including implementation of new algorithms and hybrid fusion techniques.
  - Complete data collection, analysis and validation activities, including collects at Ft. A.P. Hill and Aberdeen Proving Grounds.
  - Complete validation of end-to-end visible through near infrared (VNIR)/short wave infrared (SWIR) spectral model including real/synthetic imagery generation, atmospheric/path radiance components, sensor models, platform dynamics, and algorithm segments.
  - Complete spectral target and background signature database and release for distribution.

- Discoverer II. ($ 13.288 Million)
  - Complete Phase I satellite design efforts with two system integration (SI) contractor teams. Conduct second and third Interim Evaluation Reviews culminating in preliminary designs for demonstration satellites.
  - Conduct mission utility analyses and concept of operations studies.
  - Built and tested sub-scale radar antenna designs, advanced signal processors, and exploitation software.
  - Fly radar payload simulator on airborne asset.
  - Plan for Phase II Request for Proposals (Source Selection in early FY01).

- Novel Antennas. ($ 2.167 Million)
  - Initiate analysis of next generation geolocation techniques technology for ground based communications exploitation.

- Counter-Underground Facilities. ($ 11.440 Million)
  - Initiate robust modeling of seismic-acoustic-electromagnetic and effluent signatures and backgrounds.
  - Initiate field measurements to verify phenomenology, validate models and explore sensor deployment concepts.
  - Initiate robust modeling of coherent passive seismic-acoustic-electromagnetic monitoring of UGFs.

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- Initiate system concept development and modeling for UGF monitoring via effluents.
- Initiate robust modeling of active electromagnetic techniques for UGF characterization.
- Evaluate concepts for active seismic UGF characterization and BDA with models and field experiments.
- Initiate field measurements to verify coherent seismic-acoustic-electromagnetic phenomenology and validate models.
- Begin comprehensive evaluation of sensor deployment concepts to enable characterization to support UGF functional defeat.

- Underground Facilities Detection. ($ 1.500 Million)
  - Pursue advanced concepts and technologies to improve underground facilities detection and characterization capabilities.

- Large Millimeter Telescope. ($ 2.000 Million)
  - Initiate pointing system control design.
  - Initiate full-system pointing error budget.

(U) **FY 2001 Plans:**

- Radio Frequency (RF) Tags. ($ 7.211 Million)
  - Complete Critical Design Review (CDR) for digital RF tag.
  - Conduct risk reduction tests.

- Discoverer II. ($ 40.107 Million)
  - Conduct Phase II source selection.
  - Begin performance of Phase II: System integration (SI) contractor complete detailed design of ground moving target indicator (GMTI) radar demonstrator system.
  - Initiate procurement of long-lead items for two GMTI/ synthetic aperture radar (SAR) demonstration satellites.
  - Continue on-going signal processing and target tracking algorithm development.
  - Continue software demonstrations.

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- Counter-Underground Facilities. ($ 6.948 Million)
  - Continue modeling of signatures and backgrounds.
  - Continue field measurements to verify model performance including seismic, acoustic, electromagnetic and effluent signatures and backgrounds, and evaluate underground facilities (UGF) characterization effectiveness.
  - Initiate prototype development activities for selected technologies.
  - Initiate on-site demonstration planning.

- Non-Linear Radar Communications Mapper. ($ 7.279 Million)
  - Perform assessments of nonlinear radar phenomenon to detect critical mobile targets under camouflage and underground facilities via non-linear scattering from their communications equipment and initiate system concept development.

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

Adaptive Spectral Reconnaissance:

Source	FY 1999	FY 2000	FY 2001
Army	3.200	4.000	1.900

Discoverer II:

Source	FY 1999	FY 2000	FY 2001
NRO	29.900	13.300	34.700
Air Force	15.500	13.300	54.600

(U) **Schedule Profile:**

Plan	Milestones
Radio Frequency (RF) Tags:	
Mar 00	Conduct Preliminary Design Review (PDR) for digital Radio Frequency (RF) Tag.
Sep 00	Conduct Critical Design Review (CDR) for digital RF Tag.

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Oct 01	Brassboard digital tag.
Dec 02	Prototype digital tag.

Adaptive Spectral Reconnaissance:

Dec 00	Complete validated visible through near infrared (VNIR)/short wave infrared (SWIR) model and tools.
Dec 00	Deliver VNIR/SWIR algorithm specifications (including detection, fusion and recognition).
Dec 00	Complete VNIR/SWIR data analysis and deliver phenomenology databases.

Discoverer II:

Mar 00	Interim Evaluation Review (IER) #2.
Apr 00	Award Continuation Option to Selected System Integrator (SI) Contractor(s).
Aug 00	Interim Evaluation Review (IER) #3.
Oct 00	Phase II RFP release.
Apr 01	Award Phase II SI contract for detailed design of the demonstration system.
Jun 01	Delta-Preliminary Design Review with SI.
Jun 02	System Critical Design Review (CDR).

Novel Antennas:

Apr 00	Final data collection.
Jul 00	Wideband link demonstration.
Sep 00	Transition.

Counter-Underground Facilities:

Mar 00	Initiate model development for seismic, acoustic, and EM and effluents.
Jul 00	Initiate model validation experiments.
Dec 01	Complete Model Validation for Seismic, Acoustic, EM, and effluents.
Mar 02	Initiate prototype demonstrations.

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Non-Linear Radar Communications Mapper Program:
Aug 01 Complete initial assessment of non-linear scattering of communications equipment.

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Air Defense Initiative SGT-03	24.430	38.141	24.301	19.667	30.000	37.750	38.200	Continuing	Continuing

(U) Mission Description:

(U) This project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These programs include the Synthetic Aperture Radar Electronic Counter-Countermeasures (SAR ECCM) program, the Low-Cost Cruise Missile Defense (LCCMD) program, the Adjunct Airborne Early Warning (Global Eye) program, and the Microelectromechanical (MEM) antenna (MEM-tenna) program, and the Air Directed Surface-to-Air Missile (ADSAM) program.

(U) The SAR ECCM program will develop techniques to make U.S. Synthetic Aperture Radar (SAR) systems less vulnerable to intentional enemy jamming or deception. SAR systems have become one of the most widely used broad area surveillance systems. They are critically important to the development of battlespace awareness and their jamming and/or deception could seriously degrade U.S. warfighting capability. The SAR ECCM program will determine the military impact of various SAR jamming techniques and develop countermeasures against the highest priority threats.

(U) The LCCMD program will employ existing and emerging technologies to develop an affordable missile interceptor. This interceptor is directed at defeating a threat consisting of unsophisticated air vehicles including cruise missiles, unmanned aerial vehicles, helicopters, and low flying aircraft that are capable of delivering conventional, chemical, or biological weapons and conducting jamming or surveillance missions. The program is focused on the development of low cost seekers which account for approximately 70% of the missile system's cost and present the greatest technological challenges. The program is pursing both an RF seeker solution (noise radar and pulse doppler) and a LADAR seeker solution. The most promising seeker in terms of cost, performance, and robustness will be integrated with a Miniature Air Launched Decoy (MALD), modified to serve as an interceptor, for live fire testing and transition to the Military Services.

(U) The Adjunct Airborne Early Warning (Global Eye) program will demonstrate the feasibility of multi-aperture, multi-function radar technology in UAVs. A UAV outfitted with this technology could provide lower cost (factor of 20), continuous air and ground surveillance of low intensity areas such as no-fly zones and peacekeeping areas. Such capability could supplement traditional AWACS and E-2C, and reduce the requirement to forward base large numbers of manned aircraft for these purposes. This program will also support the demonstration of the ability to

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get an order of magnitude more ground coverage in a GMTI mode through very wide-band off-board communications and large numbers of phase centers. The key technologies to be used are: MEMs filters for simultaneous transmit and receive and polarization diversity, high efficiency solid state transmitters, composite lightweight integrated antennas, and advanced mode control/interleaving algorithms. Concepts will be explored which use common components to perform both the AEW mission (at the reduced ranges appropriate to this concept), and air-to-ground modes. The latter will support networking concepts, which reduce cost and enable precision moving surface target engagement.

(U) The MEM-tenna program will develop an ultra-low cost; lightweight phased array antenna based on MEMS phase shifters and Digital Mirror Device technologies. MEMS technology can produce phase shifters for phased array antennas that are a small fraction of the power consumption of conventional PIN-diode or GaAs field effect transistor (FET) phase shifters, while also having low insertion losses. Hard-wired beam steering control and RF manifolds are replaced by optical and RF space-fed configurations. Using these technologies, very large-scale electronically scanned arrays (ESAs) can be developed for airborne, ship and space-based applications. Phase shifter designs incorporating MEMS technology are being developed, and these will be incorporated into a prototype ESA having 10,000 antenna elements, operating at X-band.

(U) ADSAM: The purpose of the joint DARPA/AMCOM/USMC/AMRAAM program office project is to rapidly demonstrate enabling technologies and operational concepts to support the destruction of low flying, stressing targets, such as cruise missiles. This project demonstrates the critical technologies required to destroy such targets beyond the line-of-sight and at the full intercept range of surface-to-air missile systems using an elevated platform to provide target cueing and updates to Advanced Medium Range Air to Air Missiles (AMRAAM). These missiles are ground launched from modified High Mobility Multi-Purpose Wheeled Vehicles (HMMWV) developed by DARPA and AMCOM, known as the HUMRAAM.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- SAR ECCM. ($ 7.309 Million)
  - Selected ECCM techniques were implemented for mitigating low-level ECCM threats in the analog (front end) and image domain portions of the radar. Data was collected to validate the calculated impacts and support further technique development. A laboratory demonstration of the selected ECCM techniques supported several high-level experiments using test and operational platforms.

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- LCCMD. ($ 14.376 Million)
  - The Government downselected from six to three low cost seeker concepts based on the results of contractor analyses and laboratory testing. The selected seekers are the noise radar seeker, the Microelectromechanical Electronically Steered Array (MEMS ESA) seeker, and the laser seeker. The noise radar seeker team successfully completed a Critical Design Review and has begun fabrication and integration of seeker hardware to be used for captive flight-testing. The MEMS ESA seeker team fabricated and tested a MEMS phase shifter. The phase shifter, the key technology required to fabricate the MEMS seeker antenna, exceeded performance requirements. The laser seeker team fabricated and demonstrated a brassboard seeker. The seeker exceeded range accuracy requirements and came very close to meeting angle accuracy requirements.

- ADSAM. ($ 2.745 Million)
  - Modifications to the HUMRAAM developmental system were completed. Analysis of the flight test results, comparisons to predictions and model modifications were completed. Technical lessons learned, including software and hardware, was transferred to the air defense community for future ADSAM live fires with other missiles (Standard Missile, Patriot, etc).

(U) FY 2000 Plans:

- SAR ECCM. ($ 9.004 Million)
  - The design and implementation of the selected ECCM techniques will be completed and demonstrated in a series of off-line final technique demonstrations. These demonstrated techniques will begin transition into selected operational platforms to mitigate the rising proliferation of inexpensive modern threat systems. The SAR ECCM program will be integrated into the annual Expeditionary Force Exercise.

- LCCMD. ($ 16.899 Million).
  - The noise radar seeker team will complete seeker fabrication, complete seeker ground testing, and initiate non-real time captive flight testing using an A-3 aircraft and tactically representative airborne targets. The MEMS ESA seeker team will complete a Systems Requirements Review, complete a Preliminary Design Review, and fabricate and test a tactically form-factored transmit/receive antenna. The laser seeker team will complete a Systems Requirements Review, complete an Interim Design Review, and field test a

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ground based laser system against tactically representative airborne targets. The Government will select a single seeker and initiate the fabrication of a form-factored seeker for live fire testing based on the results of analyses and tests conducted to date.

- Adjunct AEW. ($ 3.485 Million)
  - Begin the development and fabrication of a subarray portion of a prototype composite, lightweight, integrated phased array antenna to demonstrate that the desired antenna concepts can be implemented while also achieving the design goals of low weight and cost. Mode control/interleaving algorithms will be developed. Also, the preliminary design for a means of carrying a complete radar system on a UAV, such as the Global Hawk, will commence.

- MEM-tenna. ($ 8.753 Million)
  - Modify existing designs of MEMS X-band phase shifters and initiate prototype manufacturing. The design of a prototype ESA that will incorporate the completed MEMS phase shifters will also begin.

(U) FY 2001 Plans:

- LCCMD. ($ 13.474 Million)
  - The noise radar seeker team will complete non-real time captive flight testing and flight test data analysis. The flight test data will subsequently be used to demonstrate in the laboratory real time processing using a noise seeker processor developed by the program. Form-factored seeker fabrication will be completed. Planning for subsequent captive carry and live fire testing will be completed.

- Adjunct AEW. ($ 3.474 Million)
  - The completed subarray will be laboratory tested.

- MEM-tenna. ($ 6.353 Million)
  - Manufacture of a full-scale antenna using MEMS phase shifters will begin. A transmitter and beam controlling processor will be integrated with the array. Calibration techniques with specific and general applicability will be developed. Planning for the final integration and test planning will start.

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- Advanced Sensing Alternatives ($ 1.000 Million)
  - Explore advanced sensing modalities to solve stressing combat ID and countermeasure challenges, including, but not limited to, IR polarization diversity and active EO/IR.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
LCCMD:	
May 00	Start Laser Seeker Ground Testing
Jun 00	Start Noise Seeker Ground Testing
Sep 00	Start Noise Seeker Flight Testing
Sep 00	MEMS ESA Antenna Testing
Sep 01	Start Selected Seeker Captive Flight Testing
Mar 02	Selected Seeker Integration with Modified MALD
Sep 02	Selected Seeker Live Fire Testing Start
SAR ECCM:	
Aug 00	Field ECCM Demonstration
Adjunct AEW:	
Mar 00	BAA Issued for MEM filter
Jul 01	Complete basic subarray fabrication and lab testing

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MEM-tenna:

Mar 00	Begin design of 10,000 element MEM-tenna demonstration system
Dec 01	Complete production of 11,000 MEMS phase shifters

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COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Sensors and Exploitation Systems SGT-04	81.943	78.869	74.206	82.720	78.286	92.582	92.832	Continuing	Continuing

(U) Mission Description:

(U) The Sensors and Exploitation Systems project funds key sensor demonstrations and the development of systems to further exploit sensor products. These efforts, in conjunction with those described in Projects SGT-01, SGT-02, and SGT-03, seek to develop the systems needed to provide the warrior with situational awareness and precision target identification and attack capability. The strategic goals of this project are to: develop key sensor technologies required to support battlefield dominance, including sensors which can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic exploitation of wide-area moderate (and high) resolution imagery; provide real-time, accurate Battle Damage Assessment (BDA); and provide semi-automated recognition, robust, precise and reliable identification, and precision fire control tracking of high value units and critical moving targets. These goals are being addressed by the Counter CC&D Program; the Semi-Automated Imagery Intelligence (IMINT) Processing (SAIP) Advanced Concept Technology Demonstration (ACTD); Moving and Stationary Target Acquisition and Recognition (MSTAR) program; Surface Target Identification for Engagement (STRIDE); Moving Target Exploitation (MTE) Automatic Target Recognition (ATR) applications programs; Eyeball, a multispectral electro-optical (EO)/infrared (IR)/radar identification concept; Airborne Video Surveillance (AVS) program; Affordable Moving Surface Target Engagement (AMSTE) program; Real-Time Battle Damage Assessment (SAR BDA) program, and the Organic Ground Moving Target Identification (GMTI) Radar (OGR) program.

(U) The goal of the Counter CC&D Program is to significantly enhance the military's capability to detect obscured targets hidden under foliage and camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (detect 80% of the targets with 0.1 FA/sq.km) using a FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR is being developed for demonstration on a manned platform (Army RC-12) providing inputs via narrowband tactical data links for ground image exploitation. A Ground Control and Display Subsystem is being developed to provide real-time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing, and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended via the Multisensor Exploitation Testbed for FOPEN as well as Multi/Hyper Spectral Image sensor input, geolocation and multi-sensor fusion processing of images, and detection of time critical targets. The program will ultimately combine FOPEN SAR on the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle with other airborne sensors (e.g., the Senior Year Electro-Optical Reconnaissance System on the U-2) and modes (GMTI/passive detection), and develop integrated exploitation technologies for insertion into the CIGSS. Analyses are also being conducted to evaluate the

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capability for FOPEN Ground Moving Target Identification (GMTI) and Electronic Support Measures to increase the effectiveness of future Counter CC&D systems.

(U) The Semi-Automated IMINT Processing (SAIP) ACTD has developed, tested and is transitioning to the operational user, automated algorithms and semi-automated tools that enhance the warfighter's capability to: process SAR, and later EO, imagery; conduct wide-area search for Ground Order of Battle and Missile Order of Battle targets; perform rapid site modeling and site monitoring; and produce target reports in near real-time (< five minutes). Goals for the baseline system were automatic target cueing and classification for a limited set of vehicles (10 targets); object level change detection; force recognition to the company level; and interactive target recognition and terrain delimitation. Goals for the enhanced system were increasing the automatic target cueing and classification to 20 targets; site modeling and monitoring with EO and SAR; and addition of SIGINT cueing. The residual-fielded system has further increased automatic target recognition to 30 targets.

(U) The goal of the Moving and Stationary Target Acquisition and Recognition (MSTAR) program is to achieve a major advance in Automatic Target Recognition (ATR) performance based on the use of SAR imagery. This is accomplished through fundamental and innovative technology and algorithmic developments, large-scale data collections, and detailed system evaluations. The approach to detecting stationary targets utilizes traditional ATR techniques to first determine suitable target candidates for those image regions of interest (ROIs) that have been selected based on their likelihood of target content. A model-driven subsystem then refines these target candidates by using a SAR signature prediction module to determine the true target ID of the target within the ROI. Other program goals include: significant advances in tools including ATR tools and capabilities to efficiently perform interactive image exploitation; development of rapid target model construction technologies; collection and dissemination of high-quality databases of SAR signatures, development of resource management systems for surveillance and exploitation; and development and demonstration of compression-based techniques to reduce communication bandwidths for SAR-based wide area search platforms to SATCOM-supportable bandwidths.

(U) The Moving Target Exploitation (MTE) program, which ended in FY 1999, provided significant improvements to the exploitation of ground Moving Target Indicator (MTI) radar data by providing previously unavailable capabilities to automatically detect, track, and classify high-value ground-moving targets and maneuvering formations using all-weather airborne surveillance radar data. Four techniques were investigated and evaluated: automatic tracking of ground moving vehicles; automatic analysis of moving vehicle motion patterns and behavior patterns to identify purposeful military movement; discrimination of desired targets from other moving vehicles using high range resolution (HRR) MTI range profiling and 1-D automatic target recognition; and imaging of specific moving targets via enhanced moving target imagery (MTIm) processing. Specific applications were targeted for MTI sensors on board the Joint Surveillance, Target, and Attack Radar System (Joint STARS), U-2, and Global Hawk

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platforms. In addition, system-level approaches for the application of complex-data techniques were investigated, developed and integrated, including scatterer-specific imaging (SSI) for enhanced ATR with reduced false-alarm rates and systematic applications of coherent change-detection (CoCD).

(U) The goal of the Airborne Video Surveillance (AVS) program is to build and evaluate Airborne Video Surveillance technology to increase the tactical usefulness of video (visible and infrared) data from manned reconnaissance aircraft and Unmanned Air Vehicles (UAVs). The following semiautomatic capabilities will be developed: Precision Video Registration (PVR): real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery from areas representing multiple terrain types (desert, mountain, littoral) using standard reference imagery products from the National Imagery and Mapping Agency; Activity Monitoring (AM): reliable detection of specific events (soldier incursion, removal of vehicles from cantonment areas, etc.) of points, operations areas and lines of communication (LOC); and Multiple Target Surveillance (MTS): simultaneous tracking of multiple ground vehicles in the sensor platform area of regard but outside a single sensor field of view.

(U) The goal of the Affordable Moving Surface Target Engagement (AMSTE) program is to develop and demonstrate the technologies required to perform affordable, all-weather, precision negation of moving surface targets (both land- and sea-based), using netted tactical and theater ground moving target indication (GMTI) sensors. Weapons system architectures will be developed and integrated to support a series of precision fire control bomb-drop field experiments and demonstrations. In-flight midcourse and terminal guidance to weapons will also be implemented to demonstrate weapon system CEPs an order of magnitude below current systems against moving targets. Experiment results will be used to extrapolate performance using multiple weapon systems, including fighter-based weapons, long-range precision weapons, and gun launched weapons. The precise cueing from the netted GMTI sensors will allow for lower-cost weapons by reducing the complexity of precision munitions. Additionally, collateral damage will be minimized by virtue of very precise targeting and midcourse/terminal phase flight updates. Robustness of the precision fire control technology will be ensured through very low-cost seekers or adaptive warheads that can compensate if fire control dropouts occur. A number of critical technologies must be developed including unaided precision gridlocking techniques, low-cost weapon data links, low-cost weapon seekers and advanced multi-platform tracking algorithms for both precision and long-duration, high-confidence track purity using phenomenological features. Additionally, battle management, command, control, and communications (BM/C3) experiments will be pursued jointly with Service partners to enable rapid inclusion of precision targeting of movers into future operational architectures.

(U) The Eyeball program, a multispectral EO/IR/Radar identification concept, is founded on the fact that prospective radar assets will be able to detect, locate and provide some forms of target classification. Because of radar and signature limitations, the identification provided may be insufficient for actual targeting and allocation of attack assets. The Eyeball program will investigate novel concepts for standoff identification of

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moving targets by electro-optical sensors working in conjunction with air- and space-born radar Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) sensors. Once identified, the targets can be tracked using the same radar-based assets. This program will test sensors combining various degrees of spatial resolution, possibly with polarimetric and spectral sensitivity, to identify targets at standoff ranges. The program will also develop concepts for providing this capability on fielded and fieldable platforms.

(U) The goal of the Real-Time Battle Damage Assessment (R/T BDA) program is to develop and evaluate technology to permit all-weather, in-theater assessment of the effects of precision weapons on mobile threat targets such as surface-to-air missile launchers, theater surface-to-surface missile launchers, and multiple rocket launchers. R/T BDA will exploit organic and theater synthetic aperture radar sensors to assess effectiveness of munitions delivery and provide feedback to attack systems in mission, with a goal of providing weapon effectiveness metric feedback to the operator within 10 minutes of engagement. R/T BDA will also develop and demonstrate very low-cost, "pop-off" sensors deployed from incoming weapons at pre-determined times before weapon impact. R/T BDA will focus on identifying and assessing weapons effects from precision guided munitions, submunitions, sensor-fuzed weapons, and weapons that typically provide less energetic effect on the target and are, therefore, more difficult to assess by traditional BDA techniques.

(U) The goal of the Organic GMTI Radar (OGR) program is to develop the technologies to enable a low-cost capability for the detection and tracking of moving vehicles and personnel through foliage, using "organic" transmit assets for Army or Marine units. The goal is to detect vehicles at ranges of 10–20 km and personnel at ranges of 3-5 km with low false alarm rates. The concept is based on the use of separate transmitters and receivers, each of which is designed for low cost and portability. False alarm reduction and target tracking will be achieved through the creation of multiple narrow azimuth receive beams using high-speed digital beam forming computers. To ensure adequate foliage penetration, the system will be designed to operate in the VHF-UHF frequency regime. The ultra-miniature receivers located at each receive antenna array will be connected to the central signal processor via fiber optic links for ease of setup and to provide for the reduced cost and weight of the overall system. The use of commercial HDTV broadcasts, as a source of illumination energy will also be included in this effort.

(U) The goal of Surface Target Identification for Engagement (STRIDE) program is to achieve confirmed identification of surface targets through a combination of rapid deployment of "eyes-on-target" and new RF phenomonologies and modeling technology. STRIDE will develop and demonstrate affordable, rapid means for delivering electro-optical systems to perform primary or secondary identification of surface targets. Delivery means may include gun launching or deploying from existing deployment mechanisms such as towed decoy tubes. These capabilities will be optimally combined with advanced RF techniques to provide reliable, affordable identification under virtually all rules of engagement. Specific

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advanced RF techniques to be investigated include the use of ultra-high bandwidth, ultra-high resolution, and multi-look with angle diversity sensing.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Counter CC&D. ($ 32.372 Million)
  - The Counter CC&D Program completed system design and neared completion of component hardware development of the FOPEN SAR Manned Airborne Demonstrator. A critical design review of the integrated Multisensor Exploitation Testbed (MSET) has been conducted in preparation for FY 2000 development tests of FOPEN and SYERS MSI exploitation and Counter CC&D Tests. Advanced FOPEN and MSI/HSI ATD/C algorithms have been extended to provide increased georegistration accuracy and potential for reduction of false alarm density through sensor fusion. Analysis of FOPEN GMTI/ESM system concepts combined with a single-aperture FOPEN GMTI/ESM data collection to verify concepts and verify attenuation models at shallow angles has been accomplished.

- SAIP ACTD. ($ 13.488 Million)
  - The Semi-Automated IMINT Processing (SAIP) operational assessment was completed and the final transition configuration of the system stood up. Demonstration of all software upgrades was conducted. Interim operational capabilities were transitioned for integration into the US Air Force Flight Test Facility and to the Army ETRAC system.

- MSTAR. ($ 20.083 Million)
  - Using data from multiple collections, including Global Hawk data acquired through the Sensor Emulation Platform (SEP) and other SAR imagery sources, the 30 target MSTAR system with extended operating conditions (EOCs) was evaluated, making use of supercomputer resources. The system performs very well against targets that articulate, against targets with variable backgrounds, configurations, and variants. The system continues to work well as the targets are placed in dirt revetments or rotate and tilt, but fails to recognize targets that are more than 10% obscured by concrete emplacements. Targets in close proximity to one another also defeat the recognition system. A laboratory for experimentation and integration of MSTAR technology into SAIP has been established in the DARPA Technology Integration Center. A pair of data collections using the ERIM DCS Ultraresolution SAR Sensor has provided a

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collection of two-inch resolution SAR images of target vehicles and military scenes. A series of MSTAR Enhancement Projects (MEP), designed to explore the use of higher resolution, the addition of new signature features, extraction of targets from raw radar returns, and increased computational parallelization were also initiated. The Rapid Target Model Insertion project, which supplies the CAD models used by the MSTAR Predictor, demonstrated two separate target model insertions with each end-to-end process occurring within a two-week time period, representing a five-fold improvement over 1997 baseline insertion rates.

- Moving Target Exploitation (MTE). ($ 16.000 Million)
  - The MTE Program demonstrated the effectiveness of MTE on-board the JSTARS T3 Testbed against a complex set of military vehicles during the Air Force Expeditionary Force Exercise. The first build of the MTE-CGS ground station was completed and demonstrated using synthetic sensor emulation platform (SEP) data. A proof-of-concept study was conducted to assess the technology to support affordable, precise, moving surface target engagement. Weapon system trade studies were conducted to investigate communication requirements, weapon system CEPs for a variety of weapon systems, weapon cost reduction, battle management requirements, and low-cost sensor-to-weapon link designs.

(U) **FY 2000 Plans:**

- SAIP ACTD. ($ 4.538 Million)
  - Operational support to the Army and Air Force SAIP residual operational capability will be provided through the second quarter of FY 2000.

- MSTAR. ($ 15.921 Million)
  - Using newly collected SAR data, the MSTAR Enhancements Program will demonstrate major improvements in ATR performance as a function of resolution. Recognition capabilities using RF returns without forming the imagery will also be investigated. An integration and transition capability will be established in the Real Time ATR Laboratory (R/T ATR Lab) for the purpose of developing MSTAR based "modules" that can be used to upgrade operational ATR systems such as SAIP. The ability to operate the MSTAR system in near real time will be demonstrated through the use of parallel super-computers in the R/T ATR Lab. Concurrently, a toolkit of interactive exploitation tools, integrated with commercial technology, will provide operationally useful ATR capabilities to image analysts. Finally, an initial exploration will be conducted of MSTAR model-based reasoning technology using SAR data in conjunction with 3-D LADAR data of ground targets.

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- AVS. ($ 11.195 Million)
  - The Airborne Video Surveillance (AVS) program will integrate, demonstrate and evaluate, extensively in laboratory systems and in some limited field experiments, airborne systems in simulated military missions with these technology goals: Activity Monitoring – upgrade to monitor activities (e.g., soldier incursion into security zones, tactical and strategic vehicle movement) in larger areas and along extended lines of communication; Moving Target Surveillance – demonstrate increased reliability of target tracking/reacquisition and develop technology for the geolocation of moving targets in multiple varieties of terrain types and imaging conditions. Precision Video Registration – demonstrate 2 meter absolute error geolocation accuracy of 80% of mission imagery (from multiple varieties of terrain types) and imaging conditions similar to reference imagery (Class 1: less than 40 degree line of sight variation, good contrast, small seasonal variations), demonstrate similar accuracy on 75% of imagery exceeding this envelope (Class 2). Activity Monitoring and Multiple Target Surveillance will perform focused experiments in support of Army, Air Force and Navy users to cause technology transition.

- Counter CC&D. ($ 27.410 Million)
  - The Counter CC&D Program will complete hardware development and system integration, and will conduct preliminary flight tests of FOPEN SAR Manned Airborne Demonstrator on an Army RC-12 aircraft. This demonstration will verify that the system meets image quality with real time tactical data link operational constraints. The Multi-Sensor Exploitation Testbed will focus on the development of SAR and spectral MSI image feature fusion techniques to demonstrate the achievable performance gain in overall detection and false alarm rate with multimode systems. These capabilities will be utilized with the ATD/C algorithms to demonstrate and project Counter CC&D capabilities in a CIGSS compliant architecture. Concept development studies and preliminary data collection experiments will be completed for FOPEN GMTI/ESM.

- AMSTE. ($ 14.805 Million)
  - A weapon system trade study of “higher-order” error terms and initial precision fire control tracking experiments will be completed. The study product will include an end-to-end operational system design, including identification of all system components, modifications required to existing systems, end-to-end concept of operations, and system performance analysis. Multisensor registration, association and tracking algorithms will be developed, and iterative experimentation will be conducted using simulated and real multi-sensor GMTI data. Two multi-sensor data collections will be conducted to provide data for tracker analysis and to investigate coordination difficulties associated with netted tracking. The design work to support real-time networked precision fire control experiments and demonstrations will begin. System developers will complete detailed definition of experiment system

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requirements and system design. Fabrication and procurement of long-lead system components, such as data links, sensor mode modifications, and precision fire control tracker real-time software development will commence. New technology development tasks will investigate techniques for using target signature data to improve track continuity and for automated management of sensor, weapons, and communications resources.

- Organic GMTI Radar (OGR). ($ 5.000 Million)
  - The Organic GMTI Radar (OGR) program will build and evaluate the brassboard proof-of-concept system. Additional data collection and propagation modeling efforts will lead to the selection of an operational frequency. Also, an experiment will be conducted using a HDTV transmitter. Planning for full scale testing and evaluation will begin.

(U) FY 2001 Plans:

- AVS. ($ 8.955 Million)
  - The Airborne Video Surveillance (AVS) program will integrate, demonstrate and evaluate extensively in laboratory systems and in some limited field experiments, airborne systems in simulated military missions with these technology goals: Precision Video Registration – demonstrate 2 meter RMS error geolocation accuracy on 90% of Class 1 and 80% of Class 2 imagery. Establish geolocation performance estimates over a wide array of global terrains for multiple algorithms.

- Counter CC&D. ($ 15.766 Million)
  - The Counter CC&D Program will conduct developmental flight tests to gather data on targets and backgrounds for algorithm training, and will perform validation flights to demonstrate that the system meets the target detection and false alarm requirements. The program will begin a yearlong phase of user demonstrations of the FOPEN SAR on the ARMY RC-12 that will be conducted with Army and Air Force exercises. Efforts will begin on rehosting MSET to SAIP residual for field demonstrations. FOPEN GMTI/ESM data analysis will be completed.

- AMSTE. ($ 29.000 Million)
  - Fabrication of new components and modifications of existing components of the field experiment system will be completed, including airborne sensors modified to support fire control, data links, ground processing with a real-time fire control tracker, and a weapon data link. A sequence of field experiments and demonstrations will be conducted to demonstrate and evaluate the capability to perform

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precision fire control targeting against moving targets. These experiments will culminate in a series of inert bomb drops on moving targets to demonstrate closed-loop weapon system precision. Field experimentation will be augmented with additional laboratory weapon system evaluations using data recorded during field experiments. Laboratory analyses will include investigation of various levels of sensor performance, use of a low-cost terminal guidance seeker, and extrapolation to operational systems. Advanced target track maintenance techniques developed in FY 2000 will be integrated into the precision fire control tracker and tested in the laboratory on recorded data to support subsequent AMSTE field experiments. Additional multiple platform GMTI data collections to support advanced GMTI precision fire control tracking will be conducted. Development of battle management tools will continue, and BM/C3 experiments will be planned with operational users.

- Organic GMTI Radar (OGR). ($ 4.000 Million)
  - The Organic GMTI Radar (OGR) program will complete the laboratory acceptance testing of hardware and software, and field experimentation will begin. Experiments will occur at multiple sites using bistatic modes with dedicated transmitters and transmitters of opportunity. Initial ROC curves will be developed and multistatic phenomenology will be verified. Also, the fabrication of a low-cost full-scale receive array will be initiated.

- Eyeball. ($ 1.985 Million)
  - Analyze data on E-O, IR, and radar to support concept feasibility and system requirements.
  - Establish sensor limits and primary trades; investigate novel concepts for cross-cued E-O, IR and radar systems.
  - Explore feasibility to exploit microdoppler target signature data for identification purposes.
  - Complete preliminary design of demonstration system.

- Real-Time Battle Damage Assessment (R/T BDA). ($ 6.500 Million)
  - Evaluate and/or develop RF algorithmic techniques and inexpensive weapon-mounted imagers to provide near real-time, all-weather assessment of precision weapons effects on high-value mobile threat targets.
  - Investigate RF techniques to exploit change detection to identify weapons-effects signatures in synchronized pre- and post-strike SAR imagery, and couple this signature assessment with real-time prediction of target functional degradation.
  - Precision munition “pop-off” BDA sensor preliminary designs will be conducted for a range of weapons.
  - Initiate data collection efforts.

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- Surface Target Identification for Engagement (STRIDE). ($ 8.000 Million)
  - Analyze a variety of electro-optical secondary identification deployment means including gun launching and deployment from towed decoy tubes.
  - Select candidates and begin preliminary designs.
  - Investigate novel RF object modeling technologies and unexplored phenomenologies such as wide dynamic range features and multi-look techniques. Optimum coupling of RF techniques with low-cost secondary identification will be determined.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Mar 00	Initial delivery of MSET MSI/SAR integrated tools.
Mar 00	AMSTE weapon system trade studies concluded.
Apr 00	OGR field experiment completed.
Jun 00	AMSTE multi-platform data collection.
Jun 00	Airborne demonstration of Airborne Video Surveillance technologies.
Jul 00	Preliminary flight demonstration of FOPEN radar on manned platform.
Jul 00	Completion of “brassboard” OGR receive antenna.
Jul 00	FOPEN GMTI/ESM concept development studies completed.
Sep 00	AMSTE real-time precision fire control laboratory experiment completed.
Sep 00	Design of AMSTE precision engagement demonstration system completed.
Sep 00	MSET integrated demonstration.
Sep 00	MSTAR demonstration of 25 different target types using full operational conditions and significant reduction in false alarm rates.
Sep 00	Completion of MSTAR Advanced Concepts evaluation.

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Oct 00	AVS precision video registration field experiments.
Jan 01	R/T BDA SAR imagery data collection.
Feb 01	Completion of Eyeball data collection plan, preliminary data analysis results.
Mar 01	AMSTE enhanced target maintenance laboratory experiment.
May 01	R/T BDA weapon deployed imager design completed.
May 01	STRIDE secondary identification preliminary designs begin.
Jun 01	Field testing of AMSTE precision fire control tracking software, sensor modes and data links completed.
Jul 01	OGR full system field demo.
Aug 01	Verification of FOPEN SAR automatic target detection and cueing.
Aug 01	STRIDE advanced RF technique evaluation completed.
Sep 01	MSET re-host to SAIP residual for field demonstrations.
Sep 01	User evaluation of FOPEN SAR operational utility.
Sep 01	AMSTE airborne precision fire control and engagement demonstration.
Sep 01	AVS field experiments for user evaluations and technology transition.
Oct 01	Completion of Eyeball preliminary design.