RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, R-1 #50					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	160.881	209.971	232.319	211.893	236.586	251.482	242.096	251.896	Continuing	Continuing
Guidance Technology SGT-01	35.275	34.189	19.666	12.231	22.633	32.964	33.764	36.564	Continuing	Continuing
Aerospace Surveillance Technologies SGT-02	19.999	65.899	71.012	70.229	73.517	90.686	77.500	84.300	Continuing	Continuing
Air Defense Initiative SGT-03	20.170	25.257	40.350	38.680	35.460	35.000	38.000	38.200	Continuing	Continuing
Sensor and Exploitation Systems SGT-04	85.437	84.626	101.291	90.753	104.976	92.832	92.832	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 six 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 activity 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; providing near-real-time exploitation of imagery data; and semi-automated target recognition and tracking.

(U) **Program Change Summary:** (*In Millions*)	**FY1998**	**FY 1999**	**FY 2000**	**FY 2001**
Previous President's Budget	167.184	213.154	232.646	204.718
Current Budget	160.881	209.971	232.319	211.893

(U) Change Summary Explanation:

FY 1998 Decrease reflects reprogramming for general reductions in PL 105-56, inflation transfer and SBIR reprogramming.
FY 1999 Decrease reflects Congressional reductions.
FY 2000 Reduction reflects Agency restructuring of priorities.
FY 2001 Increase reflects increased Agency emphasis being placed on Sensors and Exploitation Systems.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Guidance Technology SGT-01	35.275	34.189	19.666	12.231	22.633	32.964	33.764	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. GGP applications include the Army Tactical Missile System and the Multiple Launch Rocket System.

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(U) This program also will increase the ability of GPS users to operate effectively in presence of enemy jamming or countermeasures. It will demonstrate feasibility of airborne pseudolite (APL) concepts, which would sustain the availability 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 two 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, all digitally controlled GPS receiver with a space time adaptive beamforming anti-jam antenna. A digital adaptive beamformer with advanced algorithms is capable of supporting greater the 50 dB nulls against up to six different jammers.

(U) The Micro-Electromechanical 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 appropriate 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.

(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 or 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 receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS packages and advanced highly

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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 1998 Accomplishments:

- Continued fabrication and began integration of GGP Phase 2 hardware and software. ($ 18.715 Million)
- Established a second source for GGP, thereby continuing as a competitive program (Congressional). ($ 6.000 Million)
- Demonstrated proof of concept MEMS devices. ($ 3.290 Million)
- Initiated Advanced Tactical Targeting Technology (AT3) design and development. ($ 6.650 Million)
- Completed autonomous landing guidance (ALG) system installation on C-130H3, and conducted operational flight tests. ($ 0.620 Million)

(U) FY 1999 Plans:

- Perform final integration and testing of GGP units; deliver units; proceed with adaptive signal processing/beamformer to null jammers; evaluate feasibility of airborne GPS pseudolites. ($ 6.516 Million)
- Maintain a second source for GGP, thereby continuing as a competitive program (Congressional). ($ 6.500 Million)

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- Iterate MEMS foundry inertial sensor fabrication and initiate preliminary sensor testing. ($ 9.502 Million)
- Complete AT3 preliminary design and system simulation. ($ 11.671 Million)

(U) FY 2000 Plans:

- Complete evaluation of the feasibility of pseudolites; continue and complete adaptive signal processing and digital beamformer. ($ 4.000 Million)
- Complete MEMS integration with navigation software and demonstrate INS operation. ($ 7.000 Million)
- Complete AT3 brassboard fabrication and ground tests. ($ 8.666 Million)

(U) FY 2001 Plans:

- Complete refinement and evaluation of elements of the pseudolite network. ($ 2.500 Million)
- Complete demonstration of MEMS INS operation. ($ 6.000 Million)
- Conduct AT3 flight tests. ($ 3.731 Million)

(U) Other Program Funding Summary Cost:

- Not Applicable.

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(U) Schedule Profile:

Plan	Milestones
Jun 99	Complete preliminary design of the AT3.
Aug 99	Complete signal processor for digital adaptive beamformer.
Sep 99	Begin Phase 2 MEMS inertial navigation system (INS).
Sep 99	Complete critical design reviews and begin fabrication of adaptive digital beamforming GPS antenna array.
Sep 99	Deliver brassboard MEMS gyros.
Dec 99	Conduct airborne pseudolite feasibility flight tests with user GPS receivers.
Dec 99	Complete AT3 critical component demonstrations and begin brassboard fabrication.
Jan 00	Deliver GGP units to the Government.
May 00	Complete integrated demonstration of GPS receiver and adaptive digital beamforming antenna.
Jun 00	Deliver GGP units to the Government (second source).
Jun 00	Complete laboratory test of digital adaptive beamformer.
Dec 00	Complete AT3 ground tests.
Dec 00	Complete proof-of-concept flight testing of the digital adaptive beamformer.
Sep 01	Complete demonstration of MEMS INS operations.
Nov 01	Complete AT3 flight tests.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aerospace Surveillance Technologies SGT-02	19.999	65.899	71.012	70.229	73.517	90.686	77.500	84.300	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. 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 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 Radio Frequency (RF) Tags will develop the technology to allow radars (Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR)) to covertly receive data from ground devices. This program will develop a small, lightweight and affordable RF tag for data exfiltration from unattended ground sensors and communicating with Special Operations Forces and other operatives/personnel behind enemy lines. In addition, the RF tag developed can be used to identify and locate coalition forces and covertly track red forces. Additionally, the RF Tag can be used against enemy forces by modifying their return radar signal to produce virtual US ground and/or air forces. The net effect is substantially enhanced US situational awareness and simultaneously degraded enemy force situational awareness.

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(U) The Adaptive Spectral Reconnaissance Program (ASRP) will establish the technical underpinnings for real-time detection of tactical targets employing concealment, camouflage, and deception using hyperspectral sensor data from visible through long wave infrared spectral imagery. The program will develop the algorithms, models, phenomenology and advanced long wave infrared sensor technology, and verify the development on an airborne testbed. The testbed will serve as a platform to verify technical developments and conduct demonstrations of a real time tactical directed area search capability. ASRP will employ visible or near infrared (VNIR)/short wave infrared (SWIR)/long wave infrared (LWIR) spectrometers, an on board data processor with multiple algorithms, and high resolution day/night imagers to provide cues and high resolution imagery products to the analyst in support of the counter-countermeasure and deception (CC&D) mission. The developed system will be demonstrated on the ASRP testbed and subsequently on a surrogate unmanned aerial vehicle (UAV) platform.

(U) In FY1999, the Tactical Radar program is being assimilated by the Discoverer II program because of the close, inherent relationship of the two programs, and the dependency of the Discoverer II program on the success of technical advances being pursued by the Tactical Radar effort.

(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 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 2008 timeframe and a demonstrator system for the 2003 timeframe that shows the ability to achieve the proposed objective capability. Concurrent with the performance of trade studies by Discoverer II system integration contractors, results of the Tactical Radar program will be exploited, and other risk reduction initiatives will be undertaken to ensure Discoverer II system development can be pursued with acceptable risk. Specifically, the technologies to be pursued include: 1) developing a low-cost, multi-mode (Ground Moving Target Indication/Synthetic Aperture Radar (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

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data compression allowing on-ground processing with .5Gbps links, and Automatic Target Recognition (ATR) quality (.5m) range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar (IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and precision guided munitions (PGM) targeting (3m or less 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 two will be entered: the actual building and flying on-orbit of two GMTI/SAR technology demonstration satellites. That demonstration will validate the technical feasibility of: space-based GMTI detection and tracking, and moderate resolution SAR imaging, using a small, low-mass, beyond-current state-of-the-art radar antenna; theater or joint task force commander tasking of overhead GMTI and SAR collection; near-real-time, direct downlink to theater of overhead GMTI and SAR collection, using tactical ground stations otherwise planned for use with our U-2 and Unmanned Air Vehicle (UAV) airborne platforms; and, collection of high-resolution terrain mapping data, anywhere around the globe. A “go-ahead” decision to proceed with follow-on acquisition would be made after the completion of the Discoverer II demonstration program, sometime after FY2004.

(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 explored. Prior to FY 1999 the program funding was distributed amongst the component technology development programs. During FY1999, the distributed architecture has been 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) The Counter-Underground Facilities program will identify, research, develop and demonstrate high leverage technologies for characterizing and functionally neutralizing underground facilities. Such structures are increasingly employed to hide manufacture and storage of offensive weapons, including chemical, biological and nuclear weapons. The project will begin by investigating critical phenomenological unknowns related to observable signals generated by underground facilities and the backgrounds in which such signals would be detected. A series of experiments would then ensue to resolve the critical unknowns and deepen the national capability to model such structures and predict which, if any, reliable signals might be present and detectable for representative targets. Sensor techniques would then be developed and demonstrated to exploit these reliable signatures. Both remote and proximal types of technologies will be studied. Candidate technologies include, but are not limited to, laser vibrometry, low frequency electromagnetics, multi/hyperspectral imaging, seismic/acoustic imaging, laser velocimetry and micromechanical systems for close access tagging and sensing.

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(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 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) is a Congressionally mandated program to 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) FY1998 Accomplishments:

- The Millimeter Wave Targeting & Imaging System (MMWTIS) program - Completed panel review and program assessment which shifted program from Passive MMW to Millimeter Targeting and Imaging. Issued Solicitation, evaluating and awarding concept development efforts. Initiated 94 GHz signature measurements and analysis. Refined requirements and subsystem and technical specifications for transmitter and component technology. Refining 3D Synthetic Aperture Radar (SAR) algorithms. Program successfully achieved all technical milestones of targeting and imaging. ($ 4.600 Million)

- Radio Frequency (RF) Tags program - Performed analyses for multiple concepts of operation to include remote communications of sensor data from unattended ground sensors, data communications from Special Operations Forces (SOF), geo-registration of Synthetic Aperture Radar (SAR)/Moving Target Indicator (MTI) imagery, and communications of geolocation and other data between dispersed operating units. System design for each operational concept was conducted, and fabrication of brassboard Radio Frequency (RF) tags, modifications

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to airborne SAR/MTI processors and ground stations were completed. Tests were performed with the Joint Surveillance Target Attack Radar System (JSTARS) to define an RF tag system architecture and functionality. Flight tests were conducted with SAR tag designs to demonstrate a SAR tag and to design signal and image processing software. Development was initiated for ID-only and data extraction tags to be tested with SAR and MTI platforms. A CONOPS/Requirements study was completed to establish the system CONOPS, utility, value added and requirements, and a study of radar platform characteristics was initiated to evaluate suggested platforms. ($ 4.798 Million)

- Adaptive Spectral Reconnaissance program - Developed system concepts and sensor specifications. Prototyped system (NVESD Twin Otter) in flight, collecting data. Coordinated concept verification data collections occurring with Air Force Research Lab, Naval Research Lab Spectral Information Technology Assessment Center (SITAC), and Aerospace Corporation. Conducted detailed data/imagery analysis to include multiple target sets, multiple algorithms, receiver operating characteristic generation, and phenomenology assessment. Completed concept definition to include algorithm development, mission utility analysis, operational concept, sensor specification development, test plan preparation, and data analysis. Established transition partners with Army (Aerial Recce Low/Aerial Common Sensor PM) in terms of outyear POM and validated developed requirement. Worked transition issues with Air Force Unmanned Air Vehicle (UAV) Battle Lab and Air Force Recce Special Project Office (SPO). ($ 3.322 Million)

- Tactical Radar program - Developed initial algorithms supporting aerospace-based ground moving target indication (GMTI) using low-cost, light-weight, multiple phase center/receive channel antenna and 548 Mbps Common Data Link (CDL). Established feasibility of high-throughput, GMTI collection (>800 km2/sec collection rate, sustained over >6 min). Established feasibility of achieving <10 kph Minimum Detectable Velocity (MDV) for ground targets. Developed initial algorithms supporting GMTI collection performance while simultaneously collecting undergraded synthetic aperture radar (SAR) phase history data, in 3m resolution mode. Established feasibility of achieving discontinuous GMTI track correlation, and developed initial algorithms enabling GMTI target tracking. Conducted selective/limited GMTI data collection using existing airborne SAR platforms. ($ 4.395 Million)

- Large Millimeter Wave Telescope (LMT) - Source selection for systems integration contractor. Preliminary system design completed. Millimeter wave instrument demonstrated. Preliminary assessment of pointing system. Temporary road to site completed. ($ 2.884 Million)

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(U) FY 1999 Plans:

- Millimeter Wave Targeting & Imaging System (MMWTIS) – Complete concept development studies. ($ 1.000 Million).

- Radio Frequency (RF) Tags program - Complete development and testing of ID-only RF Tags for use with Synthetic Aperture Radar (SAR) and Moving Target Indicator (MTI) airborne radar platforms. Continue design of data extraction tags for low data rate communications applications. Conduct design trades for miniaturizing the tags. ($ 8.980 Million)

- Adaptive Spectral Reconnaissance program – Develop end to end spectral system model to include real/synthetic imagery generation, atmosphere/path radiance components, sensor models, and algorithm segments. Conduct joint data collects in Southeastern US (Eglin AFB), Southwestern US (National Training Center, Yuma Proving Ground), littoral zone (Bridgeport Marine Corps Station) and out(side) of the continental United States (OCONUS) (location to be determined). Continue analysis of all data, looking at algorithms, models and fusion methodology. Develop improved long wave infrared (LWIR) Hyperspectral sensor with high resolution thermal imager. Develop spectral signature phenomenology and database, and analyze large data sets. ($ 4.046 Million)

- Discoverer II program – Commence Phase I: Award multiple system integration (SI) contracts (2QFY99). Support SI contractor trade studies to define both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2004 timeframe that shows the ability to achieve the proposed objective capability. SI contracts will consist of a basic contract and an option to continue. The basic contract period of performance will extend from contract award to the completion of the second Interim Evaluation Review (IER) (including the closure of all action items). The option will conclude Phase I, starting after the second IER, and running to the third and final IER. The SI contractors will select and schedule milestones, including the three IERs, in their Integrated Master Plan/Integrated Master Schedule. Fixed payments for work completed will be tied to successfully completing these milestones. The Government will establish mission priorities and capabilities shortly after the first IER for feedback into the design trades. Support jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing, and exploitation software. Conduct mission utility analyses and concept of operations studies. ($ 31.475 Million)

- Novel Antennas program will pursue data collection, and will demonstrate algorithm performance against emitters in a realistic interference environment (urban, desert and hilly deciduous forest). Urban and non-urban environments will be explored. Distributed architectures will be developed and assessed, supporting hardware will be developed and demonstrated, and algorithm performance will be

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evaluated. The integrated system design will be developed. An experiment will also be conducted to determine the utility/synergy of close access, distributed collection capability into a distributed architecture. Networked sensors, which leverage software reprogrammable radio technology, will be employed to assess the utility of distributed architectures. ($ 13.526 Million)

- Counter-Underground Facilities program will convene a signal hypothesis working group consisting of the nation's experts in a variety disciplines critical to the counter underground facility problem including seismology, acoustics, low frequency electromagnetics, geology, and others. The working group will identify and model critical underground facility signatures, propagation phenomenology and backgrounds. It will also identify critical unknowns and define experiments to resolve them. Experiments, data analyses, and detailed modeling activities will begin. ($ 5.372 Million)

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

(U) **FY 2000 Plans:**

- Radio Frequency (RF) Tags program – Develop a miniaturized analog RF tag; Conduct a Critical Design Review (CDR) for a digital RF tag; continue development of data encoding and extraction algorithms. ($ 5.851 Million)

- Adaptive Spectral Reconnaissance program - Complete end to end spectral system model to include real/synthetic imagery generation, atmosphere/path radiance components, sensor models, and algorithm segments. Verify all data collects with model and provide predictive performance of future operational use. Complete analysis of all data. Collect testbed data with improved long wave infrared (LWIR) Hyperspectral sensor and with high resolution thermal imager and validate its performance in conjunction with the model. Provide demonstrations to users, and initiate transition process. Conduct demonstrations on unmanned air vehicle (UAV) surrogate platform. ($ 4.000 Million).

- Discoverer II program – Continue ground moving target indication (GMTI) radar satellite design efforts for three or four system integration (SI) contractor teams. Continue risk reduction activities in key areas, to include: antenna design and fabrication, advanced signal processing, and exploitation software. Conduct mission utility analyses and concept of operations studies. ($ 50.661 Million)

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- The Novel Antennas program - The Novel Antennas program will transition technology to a ground based military system for real-time urban, desert, mountain and littoral operations. Adjunct platforms will be pursued for technology transfer and system integration. ($ 1.500 Million)

- Counter-Underground Facilities program - The Counter-Underground Facilities program will continue analysis and experimentation on key observables and backgrounds. Robust modeling efforts will be initiated in critical areas previously identified, such as seismic propagation, effluent spectroscopy, and other related areas. Sensor system studies will be performed to identify critical technology initiatives, to include induced observables and other novel characterization approaches. Sensor and technology development will commence. ($ 9.000 Million)

(U) **FY 2001 Plans:**

- Radio Frequency (RF) Tags program – Complete brassboard digital RF tag; conduct operational tests of digital and miniaturized analog RF Tags in a military scenario. ($ 4.129 Million)

- Discoverer II program - Commence Phase Two: System Integration (SI) contractor(s) complete(s) detailed design of ground moving target indication (GMTI) radar demonstrator system for the 2004 timeframe that will validate the feasibility of achieving the Discoverer II program objective. Conduct critical design review (CDR) for system detailed designs. Initiate procurement of long-lead items for two Ground Moving Target Indication(GMTI)/Synthetic Aperture Radar (SAR) demonstration satellites. Continue on-going signal processing and target tracking algorithm development. Continue software demonstrations. Support jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing and exploitation software. Conduct mission utility analyses and concept of operations studies. ($ 53.100 Million)

- The Counter-Underground Facilities program will continue robust phenomenological modeling and experimentation. Selected sensors and characterization approaches will continue development. Component and system testing will begin on the most mature approaches. Field measurements will be taken to verify sensor performance and background/propagation models at selected underground facility sites. ($ 8.000 Million)

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- Non-Linear Radar Communications Mapper program: 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. ($ 5.000 Million)

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

Passive Radio Frequency Tags:

Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	1.0			

Adaptive Spectral Reconnaissance:

Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	4.0			
Army		4.0	4.0	2.0

Discoverer II:

Source	FY 1998	FY 1999	FY 2000	FY 2001
NRO	14.0	14.9	29.2	54.2
Air Force		15.5	28.7	67.2

(U) **Schedule Profile:**

Plan	Milestones
Radio Frequency (RF) Tags:	
Apr 99	Complete Radar Platform Analysis.
Jun 99	Complete ID-only Tags, radar/processing modifications.
Jun 00	Conduct Critical Design Review (CDR) for miniaturized analog Radio Frequency (RF) Tag.

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Sep 00	Conduct CDR for digital RF Tag.
Sep 01	Conduct field exercise with miniaturized analog RF Tag.

Adaptive Spectral Reconnaissance:

Mar 99	Award LWIR spectral and thermal high resolution imager system development contract.
Jul 99	Conduct Preliminary Design Review (PDR) for LWIR sensor – downselect as necessary.
Oct 99	Conduct CDR for LWIR sensor.
Aug 00	Complete final visible or near infrared (VNIR)/short wave infrared (SWIR)/long wave infrared (LWIR) flight tests.

Discoverer II:

Mar 99	Award Multiple Phase I SI Contracts.
Mar 99	Interim Evaluation Review (IER) #1.
Jun 99	Polyphase Channelizer CDR.
Jun 99	Ground Moving Target Indicator (GMTI) Tracker Software (S/W) Release.
Dec 99	Polyphase Channelizer Demo.
Dec 99	Electronically Steered Array (ESA) Transmit/Receive (T/R) Thread Test.
Dec 99	Frequency Allocation/Filing.
Dec 99	Terrain Mapping Error Model/Budget.
Mar 00	Interim Evaluation Review (IER) #2.
Mar 00	Award Continuation Option to Selected system integration (SI) Contractor(s).
Jun 00	ESA Brassboard Demo.
Jun 00	Select Final Design(s).
Mar 01	SI Contractor(s) Critical Design Review (CDR).
Jun 02	Common Data Link (CDL) Space-Qualification Mod.
Dec 02	Begin Spacecraft Integration.
Sep 03	Launch Satellite #1.
Dec 03	Launch Satellite #2.
Sep 04	Joint Program Termination.

Novel Antennas:

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Apr 99	System specification complete.
Sep 99	Demo system completed.
Apr 00	Final data collection.
Jul 00	Wideband link demonstration.
Sep 00	Transition.

Counter-Underground Facilities:

Jun 99	Preliminary phenomenological experiments defined.
Jan 00	First phase of signal/background experiments conducted.
Jun 00	Model verification complete. Sensor system development initiated.
Aug 01	Conduct sensor demonstrations.

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 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Air Defense Initiative SGT-03	20.170	25.257	40.350	38.680	35.460	35.000	38.000	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 Air Directed Surface-to-Air Missile (ADSAM) program, the Adjunct Airborne Early Warning (AEW) program, and the Micro-Electro Mechanical (MEM) antenna (MEM-tenna) 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 emerging missile seeker technologies to provide affordable approaches to defeat a proliferated threat of low cost delivery platforms. These low cost delivery platforms include cruise missiles, unmanned air vehicles, fixed wing aircraft and helicopters. These platforms are capable of conducting surveillance, performing jamming, and dispensing chemical and biological warfare agents. While the performance of these platforms is limited, when employed in large numbers, they have the potential to overwhelm our current inventory of high performance and expensive missile systems and take them away from other important missions for which they are better suited. The LCCMD program will focus on the development of affordable seekers, which are better, suited to this threat. The program is currently exploring six candidate seeker concepts. These six concepts will be narrowed down through a process of analysis, laboratory testing, and ground testing, captive flight-testing and live fire testing. A modified Miniature Air Launched Decoy (MALD) will serve as the host interceptor platform for the live fire testing. Systems successfully completing live fire testing will be transitioned to the military services.

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(U) ADSAM: The purpose of this joint DARPA/AMCOM/USMC/AMRAAM program office project is to rapidly demonstrate enabling technologies and operational concepts to support the destruction of low flying, difficult to detect targets, such as cruise missiles. This project demonstrates the critical technologies required to destroy such difficult to detect targets beyond the line-of-sight and at the full intercept range of surface-to-air missile systems. This live fire demonstration program uses 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. This demonstration program also supports the Marine's ongoing HUMRAAM program, called the Complimentary Low Altitude Weapons System (CLAWs), by allowing them to quickly progress from concept development through demonstration/validation in less than 1 year. Early successes with the HUMRAAM have led the Marines to include its further development and acquisition in their FY 2000 POM, and the Army to conduct two FY 1998 live fire tests.

(U) The Adjunct Airborne Early Warning (AEW) program will demonstrate the feasibility of ultra-lightweight, 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 peace keeping areas. Such capability could supplement traditional AWACS and E2-C, 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 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 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 (DMD) technologies. MEM technology can produce phase shifters for phased array antennas that are a small fraction of the power consumption of conventional PIN-diode or GaAs 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 MEM technology are being developed, and these will be incorporated into a prototype ESA having 10000 antenna elements, operating at X-band.

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(U) Program Accomplishments and Plans:

(U) FY 1998 Accomplishments:

- SAR ECCM: The study panel updated their analyses of intelligence, surveillance and reconnaissance (ISR) SAR ECM vulnerability and candidate ECCM technique performance. Low cost ECM techniques were analyzed and synthetic data was generated to provide a baseline for ECCM algorithm development. Data was collected against ECM threats with an operational ISR system. Algorithm development and performance analysis of ECCM techniques applicable to a broad range of of ISR radars has begun. ($ 5.238 Million)

- LCCMD: Six seeker efforts were initiated during this year. The noise radar seeker contract to perform a captive flight test was initiated. The noise radar contractor successfully passed a System Requirements Review milestone. The Micromechanical Electromagnetic (MEMS) Electronically Steerable Array (ESA) seeker contract to perform risk reduction testing was initiated. The MEMS ESA contractor conducted design trades and analyses during this period. The laser seeker and infrared seeker contracts were initiated to perform seeker concept development studies and limited laboratory testing. The optical ESA antenna and UHF antenna contracts were initiated to perform antenna concept development and limited laboratory testing. The four concept development contractors presented their detailed program plans and concepts at kick-off meeting with the Government. ($ 10.060 Million)

- ADSAM: Two successful "dry runs" of the complete ADSAM architecture were conducted in 2nd QTR FY 1998. During the 3rd QTR two tests were conducted in which HUMRAAM missiles were launched against low-flying cruise missile targets. A live fire test was accomplished during the 4th QRT using a live warhead AMRAAM missile. Following completion of this demonstration, the residual assets (2 HUMRAAMs with associated hardware and software) were provided to the Marine Corps to support their ongoing Complimentary Low Altitude Weapons System (CLAWS) program. ($ 4.872 Million)

(U) FY 1999 Plans:

- SAR ECCM: The hardware and software implementation of candidate SAR ECCM algorithms applicable to Sensor Emulation Platform (SEP) will commence. Selected ECCM techniques will be implemented for mitigating low-level ECM threats in both the analog (front end) and image domain portions of the radar. Additional data will be collected to support technique development. A laboratory

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demonstration of the selected ECCM products will occur. Design efforts and test planning will get underway in preparation for a proof of principle demonstration scheduled for FY 2000. ($ 7.850 Million)

- LCCMD: The noise radar seeker will be focused on the design and fabrication of a seeker in preparation for captive flight-testing. Both Preliminary Design Reviews and Critical Design Reviews will be completed for the noise seeker and the airborne test instrumentation. Fabrication of the noise radar seeker and airborne instrumentation will continue through the end of the year. The MEMS ESA risk reduction effort will be completed with final results of system trades and laboratory testing of a subarray. The four concept development efforts will be completed with final results of system trades and limited laboratory testing. The Government will select the most promising concepts based on the results of the risk reduction and concept development contracts to proceed to ground testing. ($ 14.617 Million)
- ADSAM: Modifications to the HUMRAAM developmental system will be completed. Analysis of the flight test results, comparisons to predictions and model modifications will be completed. Technical lessons learned, including software and hardware will be transferred and implemented, if possible, to the air defense community for future ADSAM live fires with other missiles (Standard Missile, Patriot, etc). ($ 2.790 Million)

(U) **FY 2000 Plans:**

- SAR ECCM. The design and implementation of the selected ECCM techniques will be completed and integrated on-board the SEP test bed and an operational ISR sensor platform. A proof-of-principle demonstration will be conducted with real-time in-flight jamming and processing. ($ 9.050 Million)
- LCCMD: The noise radar seeker fabrication will be completed. The noise radar seeker will undergo extensive ground tests, be integrated into an A3 aircraft, and captive flight-testing will be initiated. Those seekers selected for ground testing will be fabricated and undergo extensive ground testing. The Government will select the most promising concepts based on the result of the ground testing contracts to proceed to captive flight and live fire testing. Design modifications to the MALD to make it suitable for an interceptor will be initiated. ($ 21.000 Million)

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- Adjunct AEW: 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. ($ 2.500 Million)

- MEM-tenna: 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. ($ 7.800 Million)

(U) **FY 2001 Plans:**

- SAR ECCM: An operational real-time demonstration will be conducted with the modified SEP platform against a set of recognized and non-recognized ECM threats. The effectiveness of the DARPA developed ECCM techniques will be qualitatively evaluated by image analyst assessment of SAR image interpretability and quantitatively evaluated by using current state-of-the-art automatic target recognition (ATR) software. ($ 5.000 Million)

- LCCMD: The noise radar seeker captive flight test will be completed and test results will be analyzed. The Government will determine whether the noise seeker will proceed to live fire testing. The fabrication of the other seekers selected for testing will be completed and captive fight testing will be initiated. Design modifications to the MALD will be completed. ($ 20.500 Million)

- Adjunct AEW: The completed subarray will be laboratory tested. The full-scale design and integration of an airborne phased array antenna will commence. Also, the manufacture of a prototype for an external pod, or other means for carrying a final radar system, will commence. Planning for the final radar system integration and testing will begin. ($ 6.000 Million)

- MEM-tenna: 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. ($ 7.180 Million)

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(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
LCCMD:	
Apr 99	Infrared Seeker Laboratory Demonstration
Apr 99	Optically Steered ESA Antennas Laboratory Demonstration
Apr 99	UHF Antenna Laboratory Demonstration
May 99	Laser Seeker Laboratory Demonstration
Jan 00	Noise Seeker Captive Flight testing Start
Sep 00	Selected Seeker Ground Testing Start
Jun 01	Selected Seeker Captive Flight Testing Start
Sep 01	Selected Seeker Integration with Modified MALD
Mar 02	Selected Seeker Live Fire Testing Start
SAR ECCM:	
Aug 99	Laboratory ECCM Demonstration
Aug 00	Field ECCM Demonstration
Adjunct AEW:	
Nov 00	Begin development and testing of low-cost, multi-function antenna subarray and algorithms
Nov 01	Begin full scale design and fabrication of phased array antenna

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MEM-tenna:

Jul 00	Initiate prototype phase shift manufacturing
Dec 01	Complete 11,000 MEM phase shifters
Mar 02	Full scale antenna fabrication using MEMs phase shifters

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Sensor and Exploitation Systems SGT-04	85.437	84.626	101.291	90.753	104.976	92.832	92.832	92.832	Continuing	Continuing

(U) Mission Description:

(U) The development efforts described herein embody key sensor demonstrations and the exploitation of sensor products. These efforts, in conjunction with those described in Projects CCC-02 and SGT-02, seek to develop the systems needed to provide the warrior with situational awareness and precision targeting 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; and provide semi-automated recognition and precision 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); the Sensor to Shooter to Weapon (SSW); Moving and Stationary Target Acquisition and Recognition (MSTAR) program; Moving Target Exploitation (MTE) Automatic Target Recognition (ATR) applications programs; Airborne Video Surveillance (AVS) program; Affordable Moving Surface Target Engagement (AMSTE) program, and the Organic 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 natural and artificial camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (0.1 FA/sq.km max) using a FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR will be 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 (GCDS) is being developed to provide real time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing (ATD/C), and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended for FOPEN as well as Multi/Hyper Spectral Image (MSI/HSI) sensor input, geolocation and multi-sensor fusion processing of images, and detection of time critical targets. The program will ultimately combine FOPEN Radar on the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) with other airborne sensors (e.g., the Senior Year Electro-optical Reconnaissance System (SYERS P31) on the U-2) and modes (GMTI/passive detection), and develop integrated exploitation technologies for insertion into the CIGSS. Analyses will also be carried out to evaluate the capability

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for FOPEN Moving Target Identification (MTI) and Radio Frequency Intelligence (RFINT) for increasing the effectiveness of Counter CC&D on future system designs.

(U) The Semi-Automated IMINT Processing (SAIP) ACTD will develop, test and transition 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 are 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 an enhanced system are increasing the automatic target cueing and classification to 20 targets; site modeling and monitoring with EO and SAR; and addition of SIGINT cueing. An enhanced-fielded system will further increase 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 SAR. This is accomplished through fundamental and innovative technology developments, large-scale data collections, and detailed system evaluations. The approach to detect 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. To handle moving targets, one-dimensional model-based analysis of radar returns from multiple viewpoints will be used to perform identification. 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; collection and dissemination of high-quality databases of SAR signatures, development of resource management systems for surveillance and exploitation, and development and demonstration of ATR- and compression-based techniques to reduce communication bandwidths for SAR-based wide area search platforms to SATCOM-supportable bandwidths. The latter uses statistical representation of the background to perform aggressive compression and wavelet-based approaches to compress detected targets to maintain signature fidelity and is referred to as "intelligent bandwidth compression."

(U) The Moving Target Exploitation (MTE) program's objective is to provide 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-valued ground-moving targets and maneuvering formations using all-weather airborne surveillance radar data. Four techniques are being investigated and evaluated: the automatic tracking of ground moving vehicles; the automatic analysis of moving vehicle motion patterns and behavior patterns to identify purposeful military movement; the discrimination of desired targets from other moving vehicles using high range resolution (HRR) MTI

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range profiling and 1-D automatic target recognition; and the imaging of specific moving targets via enhanced moving target imaging (MTIm) processing. Specific applications are targeted for MTI sensors on board the Joint Surveillance, Target, and Attack Radar System (Joint STARS), U-2, and Global Hawk platforms. In addition, system-level approaches for the application of complex-data techniques will be 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): the real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery using precision geo-referenced orthomosaics as reference imagery; Activity Monitoring (AM): the 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): the simultaneous tracking of multiple ground vehicles (up to 12 targets)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). The use of netted ground moving target indication (GMTI) sensors will be explored using existing and planned sensors to produce a precision ground moving target fire control solution. Integrated weapons system architectures will be evaluated and demonstrated which include netted air-to-ground GMTI sensors; fighter-based weapons, long range precision weapons, and gun launched weapons. In-flight midcourse and terminal guidance to weapons will also be explored to drive weapon system CEP's an order of magnitude below current systems against moving targets. The precise cueing from the netted GMTI sensors will allow for lower cost weapons by reducing the complexity of, or eliminating entirely, the weapon's terminal guidance seekers. Additionally, collateral damage will be minimized by virtue of the very precise targeting and midcourse/terminal phase flight updates. The AMSTE program will begin with a thorough characterization of GMTI sensor fire control feasibility including advanced multi-sensor tracking and association algorithms, Space Time Adaptive Processing (STAP) to reduce sensor minimum detectable velocity and multi-sensor data collection/analysis to verify fire control accuracy predictions. Communications and weapons system studies will also be conducted to minimize weapon cost.

(U) The goal of the Organic GMTI Radar (OGR) program is to develop the technology to enable a low cost capability for the detection and tracking of moving vehicles and personnel, through foliage, using "organic" assets for Army or Marine units. The goal is to detect vehicles at ranges

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of 10 – 20 km and personnel at ranges out to 10 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 alarms and 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 potential source of illumination energy will also be evaluated in this effort.

(U) The goal of the Congressionally-mandated Geographic Synthetic Aperture Radar (GeoSAR) Program is to develop and test an airborne, radar-based foliage penetration/terrain feature mapping and geographic information system with an emphasis on both defense and civil applications. This program will be completed with FY 1998 funding and transitioned to Army Topographical Engineering Center in early FY 2000 for user validation.

(U) Program Accomplishments and Plans:

(U) FY 1998 Accomplishments:

- The Counter CC&D Program's Foliage Penetration (FOPEN) SAR completed Critical Design Review (CDR) for test and evaluation on a manned platform which will provide inputs via narrowband tactical data links to the image exploitation capabilities in a dedicated Ground Control and Display Subsystem (GCDS). The Image Exploitation techniques developed under SAIP have been extended to include unique characteristics of VHF/UHF band FOPEN radar, high spatial resolution U2 SYERS MSI sensor, multisensor image registration and geo-location and object correlation to improve the reliability of detection and discrimination of tactical targets under camouflage and foliage cover. Data from the FY97 Keystone97 Counter CC&D exercises have been processed to verify FOPEN SAR's ability to reliably detect tactical targets, georegistration of SAR with MSI and X-Band imagery, and show feasibility of meeting ADT/C objectives of 0.1 False Alarm per square kilometer. A feasibility study was carried out for adding FOPEN MTI and RFINT within the FOPEN architecture. Automated spectral exploitation processing techniques were implemented in an integrated software environment using data from the FY97 Dixie MSI collection. ($ 21.000 Million)

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- The GeoSAR Program completed the development of the foliage penetration, mapping radar and integrated it on a contractor-furnished aircraft. The Image Formation Processor and Geographic Information System have been baselined in preparation for user validation flight tests. ($ 10.010 Million)

- Semi-Automated IMINT Processing (SAIP) integration and field-testing continued towards transition system objectives with initial operational deployment of the enhanced SAIP system. Formal military utility assessment was conducted with Army and Air Force operational users under US Atlantic Command (USACOM) sponsorship. System assessment was conducted by a team from USACOM and the National Imagery and Mapping Agency. Enhanced SAIP capabilities were provided to support the Global Hawk UAV SAR, the U-2 ASARS-2, and the U-2 SYERS sensor. ($ 23.894 Million)

- The MSTAR target recognition system matured into a system that was capable of identifying 20 different target types while having the ability to handle realistic target imagery under a variety of operating conditions, including target articulations and obscurations. During FY98 the system MSTAR program developed, used, and disseminated a large database of target and clutter imagery. The Electronic systems Center (ESC) and the Aeronautical Systems Center (ASC) have roadmapped the intelligent bandwidth compression technology for transition to JSTARS and ASARS Improvement Program. Full prototypes for the interactive exploitation of two different image analyst missions were also developed and evaluated. A rapid target insertion prototype system was built and evaluated, creating 5 target models and rapid ATR training systems as baseline. Resource management of the target recognition search process was prototyped and evaluated. An integrated, real-time demonstration of intelligent bandwidth compression using U2 and Global Hawk (utilizing the Sensor Emulation Platform) in support of potential SAIP or MSTAR exploitation was conducted. ($ 15.547 Million)

- The MTE program demonstrated real-time operational MTE performance against high-value moving targets by integrating the classification component and simulation testbeds developed in FY 1997 into a single MTE system testbed and flown onboard the Joint STARs T3 testbed. The MTE program successfully tracked and identified a high value moving surface target during the AF EFX98 experimental exercise. In parallel, more extensive tools have been developed, and exercised and evaluated in a ground station simulation testbed. A ground station simulation testbed has emulated the MTE data that will be available from the Global Hawk platform. Two advanced techniques, scatterer-specific imaging (SSI) and coherent change detection (CoCD) have been adapted to operate with the X-band class of radar sensors. Performance analyses for the robustness of the coherence-based techniques with X-band sensors were completed and analyses for the benefit of using these techniques to aid GMTI tracking have begun. Finally, an initial analysis and

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simulation was conducted (leveraging the GMTI tracking knowledge and tools developed under the MTE program) that illustrated the feasibility of using GMTI radars as netted fire control radars to provide precision targeting against surface moving vehicles. ($ 14.986 Million)

(U) FY 1999 Plans:

- The Counter CC&D Program will complete integration of a FOPEN SAR Manned Airborne Demonstrator with a tactical data link and a Ground Control and Display System to verify Global Hawk HAE UAV performance goals. A laboratory demonstration of the Multisensor Exploitation Testbed (MSET) will be 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 will be extended to provide increased georegistration accuracy and potential for reduction of false alarm density through sensor fusion. Analysis of FOPEN MTI/RFINT system concepts will be combined with a FOPEN/SIGINT data collection to verify concepts and verify attenuation models at shallow angles. ($ 33.523 Million)

- The SAIP Operational Assessment will be completed and the final transition configuration of system stood up. Demonstration of all software upgrades will be conducted. Interim operational capabilities will be transitioned for integration into the US Air Force flight test facility and to the Army ETRAC system. ($ 13.609 Million)

- The evaluation of the 20 target MSTAR system with full extended operating condition (EOC) will be expanded using the new data collections, including Global Hawk data acquired through the sensor emulation Platform (SEP). Scalability of the MSTAR system will be demonstrated by extension to a 25-target capability. MSTAR based technologies will be integrated with SAIP and STARLOS technology and transition to a real time demonstration system will begin. Also, a three-year effort to develop an MSTAR model-driven ATR system will begin to accommodate moving targets using MTE technology. Multiple modes of radar processing (high range Resolution, Inverse SAR, phase history) shall be utilized to improve performance on moving and stationary targets. Development and evaluation of rapid target insertion and interactive exploitation systems will continue, with key milestones occurring in FY 2000. ($ 21.494 Million)

- The MTE Program will demonstrate and evaluate the effectiveness of MTE on-board the JSTARs T3 Testbed against a complex set of military vehicles. The SEP testbed will be completed and GMTI data will be collected and used to validate a synthetic SEP data generator. The first build of the MTE-CGS ground station will be completed and demonstrated using synthetic SEP data. Additional

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studies and analyses will develop and assess the technology to support affordable, precise, moving surface target engagement. Weapon system trade studies will be conducted to investigate communication requirements, weapon system CEPs for a variety of weapon systems, weapon cost reduction, BM/C3 requirements, and low cost sensor to weapon link designs. Multi-platform automated GMTI precision association and tracking algorithms will be developed and exercised using data collecting by employing existing GMTI sensors in a coordinated simultaneous collection architecture. ($ 16.000 Million)

(U) **FY 2000 Plans:**

- Operational support to the Army and Air Force SAIP residual operational capability will be provided through the second quarter of FY 2000. ($ 4.532 Million)

- The MSTAR system will become the ALL-STAR system (ALL-Situation Taskable ATR for Radar), has the goal of an ATR system capable of dealing with both moving and stationary targets using a common reasoning system. The All-STAR program, which is based on the MSTAR technologies, will be able to identify 30 different target types, where the targets can be operating under varying conditions, including motion, background, articulation, obscuration, configuration, and target manufacturing variations. Incorporating technology from the SAIP program to analyze force structure and make use of context, false alarm rates on newly collected clutter data representative of operational challenges will drop to one per 200 square kilometers. Using distributed parallel computing, a near time system will demonstrate recognition capabilities of stationary targets. Also, a toolkit of interactive exploitation tools integrated with commercial technology will provide operationally useful ATR capabilities to image analysts. The rapid target model insertion project will demonstrate the ability to incorporate a new target model into the All-STAR system within two weeks, representing a five-fold improvement over 1997 MSTAR baseline rates. ($ 18.521 Million)

- The AVS program will integrate, demonstrate and evaluate airborne and laboratory systems in a simulated military mission with these technology goals: Activity Monitoring - upgrade to monitor activities (e.g. soldier movement, tactical and strategic vehicle movement) in larger areas and along extended lines of communication; Moving Target Surveillance - demonstrate increased reliability of 3 target tracking/reacquisition and scaled development to track 6 targets; Precision Video Registration - Demonstrate 2 meter RMS error geolocation accuracy on 80% of mission imagery 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).
($ 10.289 Million)

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- The Counter CC&D Program will complete verification of FOPEN SAR imaging and target detection on the Army RC-12 Airborne Demonstrator. Real time surveillance will be demonstrated via a tactical data link and a Ground Control and Display System. A series of tactical demonstrations will be conducted with Army and Air Force exercises to validate the operational utility of the FOPEN SAR. The Multi Sensor Exploitation Testbed will be utilized to project Counter CC&D Exploitation capabilities in a CIGSS compliant architecture. Concept Development studies and preliminary data collection experiments will be completed for FOPEN MTI/RFINT. ($ 31.200 Million)

- The Affordable Moving Surface Target Engagement (AMSTE) Program will leverage the exploratory work for precise engagement of moving surface targets that was begun under the MTE program. The weapon system trade study and initial non-real-time precision fire control tracking experiments will be completed. Multisensor registration, association and tracking algorithms will continue to be developed, and iterative experimentation will be conducted. The design work to support real-time networked precision fire control experiments will begin; the goal is to support at least two competing AMSTE contractors throughout the experimentation. Critical enabling technologies will begin development including, but not limited to, low cost weapon data links, automated endgame BMC3 sensor control algorithms/software, etc. ($ 25.000 Million)

- The Organic GMTI Radar (OGR) program will build upon technologies developed under the Counter CCD program to initiate the fabrication of a low-cost full-scale receive array and complete the fabrication of the radar signal processor, beam forming computer, and solid state transmitter. Planning for full scale testing and evaluation will begin. ($ 11.749 Million)

(U) **FY 2001 Plans:**

- The All-STAR system will deal with a hundred different target types, using targets generated with the efficiencies afforded by the Rapid Target Model Insertion developments. The emphasis will be on maintaining an ability to treat targets under realistic conditions, and to be able to incorporate algorithmic methods that permit the tasking of collection assets to maximally improve recognition capabilities (Active ATR). For moving targets, the recognition capabilities developed in the ALL-Star project will be integrated with tracking capabilities developed elsewhere to improve recognition rates based on multiple views. Recognition capabilities will be able to fuse radar information from targets while they are moving as well as information acquired when they are stationary. To image moving targets, inverse SAR methods (ISAR) will be investigated to integrate with other information to improve recognition and decrease false alarms. ($ 8.000 Million)

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- The AVS program will integrate, demonstrate and evaluate airborne systems in simulated military missions with these technology goals: Activity Monitoring - increased reliability and coverage for point, area and LOC monitoring; Moving Target Surveillance: Demonstrate tracking/reacquisition of 12 targets; Demonstrate 2 meter RMS error geolocation accuracy on 90% of Class 1 and 80% of Class 2 imagery. ($ 8.000 Million)

- The Counter CC&D Program will complete development of concepts of operation, and hold Readiness Review and Test and Evaluation review for Demonstration #3, FOPEN image interpretation with MSET at 60 sq km per minute at 40 km range, and demonstrate operational detection of user-specified threats at .01 FA per sq km. ($ 19.753 Million)

- The Affordable Moving Surface Target Engagement (AMSTE) Program will continue the development of critical networked precision fire control GMTI tracking technologies. The detailed design and modification of existing system components will be completed to support multiple real-time precision fire control tracking experiments; the required sensor, data link, processor, BMC3 infrastructure, and target ground truthing modifications will be made. Additional subsystem modifications will continue to support subsequent AMSTE weapon system experimentation, including weapon modifications. If required, additional multiple platform GMTI data collections to support advanced GMTI precision fire control tracking will be conducted. ($ 37.000 Million)

- The Organic GMTI Radar (OGR) program will complete the fabrication of the receive array and software required for laboratory and field-testing. Hardware and software will undergo laboratory acceptance testing 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. ($ 18.000 Million)

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Mar 99	Start MSET SYSTEMS Integration.

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Apr 99	MTE weapon system trade studies and precision fire control tracking studies initiate.
Apr 99	Airborne MTE demonstration with Joint STARS.
May 99	FOPEN MTI/RFINT collection at Ft Gordon on Army Moving Targets.
Jul 99	Complete integration of SAIP transition configuration.
Jul 99	GeoSAR foliage penetration interferometric mapping validated.
Aug 99	MTE Multiple platform GMTI data collection.
Sep 99	Non-real-time precision fire control laboratory experiment
Sep 99	Flight demonstration of FOPEN radar on manned platform.
Nov 99	GeoSAR transition to user completed.
Nov 99	Final MSTAR ATR demo: 25 targets, full range of EOC's, integration with interactive exploitation tools, SEP data.
Jan 00	Initial Delivery of MSET MSI/SAR Integrated Tools
Mar 00	AMSTE weapon system trade studies concluded
May 00	Verification of FOPEN SAR Automatic Target Detection and Cueing.
May 00	FOPEN MTI/RFINT Concept Development Studies complete.
May 00	AMSTE multi-platform data collection.
Jun 00	Completion of "brassboard" OGR receive antenna
Jun 00	Airborne demonstration of Airborne Video surveillance technologies.
Jul 00	Delivery of Refined MSET MSI/HIS/SAR Integrated Tools
Jul 00	Participate in Army Warfighting Experiment.
Sep 00	AMSTE laboratory precision fire control experiment completed
Sep 00	CARABAS Testing Effort Joint US Campaign
Nov 00	All-STAR demonstration of 30 different target types using full operational conditions and significant reduction in false alarm rates.
Jul 01	Near Real-Time Implementation of MSET MSI/HIS/SAR Integrated Tools
Sep 01	AMSTE real-time precision fire control field experiment
Nov 01	All-STAR demonstration of a system having a hundred target type capability.