Sensors, Electronics, and Electronic Warfare

SE.03 Advanced Radar Processing From Airborne Platforms

Objectives. Address identified needs for performance upgrades to both Air Force and Navy airborne early warning radar sensors and the development of a lightweight synthetic aperture radar/moving target indicator (SAR/MTI) radar for tactical Army unmanned aerial vehicle (UAV) platforms; develop and incorporate advanced space–time adaptive processing (STAP) algorithms into existing lookdown airborne sensors providing clutter suppression 30 dB beyond that currently achievable; and develop lightweight SAR/MTI payloads for tactical UAVs emphasizing Longbow algorithms, wavelets, and commercial off-the-shelf products.

Payoffs. This DTO will provide the warfighter with information superiority of the battlespace in a multiplicity of environments. In FY99, a 15-dB improvement in J-hook clutter suppression on an airborne STAP testbed was demonstrated and radar weight of less than 80 lb was achieved.

Challenges. STAP techniques that are amenable to existing airborne platforms, such as the E–2C, need to be developed. Investigation of low-cost modifications are required to be coupled with algorithms that deliver the required performance. For UAVs, the challenges include the ubiquitous issues of cost, weight, volume, modest antenna size, and low-velocity platform data processing.

Milestones/Metrics.

FY2000: Demonstrate low-cost, lightweight SAR/MTI with 70% probability of detection and false-alarm rate of two per minute at ranges greater than 12 km for MTI and 5 km for SAR.

FY2001: Complete performance testing. Participate in AEWs using modular radar and IR sensors for aircraft.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Charles CHRISTIANSON SFAE/PEO/IEW&SD	Mr. Jeff SICHINA ARL	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.03 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602702F	4506	0.7	0.0	0.0	0.0	0.0	0.0
0603772A	243	3.9	2.9	0.0	0.0	0.0	0.0
	DTO Total	**4.6**	**2.9**	**0.0**	**0.0**	**0.0**	**0.0**

SE.05 Automatic Radar Periscope Detection and Discrimination

Objectives. Demonstrate advanced radar technology for surface and airborne radars to automatically detect exposed periscopes in the presence of sea clutter and small targets and debris found in the littoral environment. The Navy's current periscope detection airborne radar, the AN/APS–137, is being enhanced by developing and integrating automated detection and discrimination technology, along with automatic target classifier/recognition processing, to enable rapid distinction of periscopes in the complex clutter (sea clutter, floating objects) typical of littoral operating environments.

Payoffs. With the end of the cold war, Navy mission needs have shifted from blue (open ocean) to brown (littoral) waters. Regional conflict involvement requires protection of fleet units from submarine torpedo attack in shallow water, where acoustic sensors perform poorly. The Third-World diesel-electric submarine threat provides significant periscope detection opportunities. Airborne technical assessments of radar processing techniques that provided greater than 50% probability of detection for short periscope exposures were successfully conducted.

Challenges. The primary technical challenge is the radar signal processing and implementation to achieve adequate probability of rapid detection in conditions of high-clutter backgrounds associated with low grazing angles and littoral environments.

Milestones/Metrics.

FY2000: Complete airborne technical assessments. Complete performance analysis. Document technical and operational utility performance, as-tested design, and recommended design features for transition.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Gary SNIDER NAVAIR	Dr. Dave JOHNSON ONR	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.05 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603747N	R2142	3.0	0.0	0.0	0.0	0.0	0.0
	DTO Total	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

SE.06 Next-Generation Multifunction Electro-Optical Sensor System

Objectives. Develop and demonstrate a highly stabilized infrared search and track (IRST) sensor and signal processing technology for air and seaborne platforms. Specifically this DTO will pursue development of next-generation IRST system technology with active laser adjunct that incorporates lessons learned in previous developments such as Navy's Shipboard IRST, E2C surveillance IRST and BMDO/Navy unmanned aerial vehicle–boost phase intercept (UAV–BPI). Recent advances in large-area infrared focal plane arrays (IRFPAs) (DoD Electronics programs), multidimensional signal processing (services), integrated passive/active optical apertures (Navy), and electromechanical stabilization technology (services/industry) coupled with the technology base realized from prior work form the system building blocks. On-going investigations into development of efficient "plug-and-play" system architectures to enable cost-effective scaling of sensor characteristics to platform and mission needs are continuing. For example, the active laser element of the system could be integrated only in systems for platforms such as Aegis and E2C that require precision range tracking at extended ranges for fire control purposes. Such architectures are driven by the need to reduce system cost and complexity where possible and to mitigate the prohibitive cost and risk of integrating new and emerging technologies as future system improvements become necessary.

Payoffs. Technologies resulting from this DTO will significantly improve the warfighter's ability to organically acquire, identify, and accurately track in three dimensions (azimuth, elevation, range) airborne threats over a wide panoramic field of regard. In addition to significantly increased situational awareness, the operating forces will have the ability to detect and discriminate theater ballistic missile (TBM) during boost phase out to ranges in excess of 1,500 km and cruise missiles out to the sensor horizon. The multicolor detectors employed will also enable tracking of the vehicle hard body at comparable ranges during both powered and unpowered phases of flight. High-power coherent lasers (where applicable) add the additional parameters of precision range tracking and target identification through high-range resolution and micro-Doppler recognition techniques. Precision track parameters, such as 0.5 deg azimuth and elevation and 500 km for TBMs, coupled with combat ID provide significant gains in fire control quality and provide the ability to effectively engage both TBM and cruise missile targets at ranges well beyond the sensor horizon of the launch/engaging platform.

Challenges. Technical challenges include development and maturation of high-power coherent lasers with adaptive operating characteristics to mitigate environmental effects on propagation/coherence length. Challenges further include development of integrated electronically stabilized passive/active optical apertures. Even though focal plane array and signal processing technologies have advanced significantly, issues associated with system- and mission-specific tailoring of the operating characteristics remain.

Milestones/Metrics.

FY2000: Complete flight tests of E2C surveillance IRST and of the BMDO/Navy-developed UAV–BPI sensors. Assess state of technology of critical subsystems such as IRFPAs, electronic stabilization, high-power coherent lasers, and common apertures/optics.

FY2001: Initiate system design.

FY2002: Complete system development and conduct initial laboratory and field testing to verify system performance.

FY2003: Integrate into E2C aircraft and conduct full performance testing in varying background and target conditions. Transition to PEO–T, PMA–231.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT Lee LILLY, USN PEO–T, PMA–231	Mr. Dave MASTERS ONR 31	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.06 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602232N	00000	1.5	2.0	2.0	2.0	0.0	0.0
0602702E	TT–06	6.4	0.0	0.0	0.0	0.0	0.0
0603203F	665A	2.0	3.0	3.5	2.0	0.0	0.0
	DTO Total	**9.9**	**5.0**	**5.5**	**4.0**	**0.0**	**0.0**

SE.09 Multiwavelength, Multifunction Laser

Objectives. Develop and demonstrate high-efficiency, compact, laser-diode-pumped laser radar (LADAR) systems in the 0.26-µm to 12-µm spectral region. The multifunctionality of single-wavelength, solid-state sources will also be investigated as a means of maximizing their utility.

Payoffs. This DTO develops a tunable (0.26–12 µm) multifunction laser capable of precision range (<1 m at 20-km target range) and velocity (<1 mm/s) measurements with sufficient repetition rate (200–1000 Hz) to support a target vibration analysis and target profiling. The resulting laser source technology will provide the warfighter the ability to accomplish multiple goals such as LADAR, rangefinding, target degradation, combat identification, wind shear determination, obstacle avoidance, and secure communications using a single laser system. Modules with multiple wavelength outputs that meet technical requirements (<1-m range resolution and <1-mm/s velocity resolution) were successfully developed. In FY99, multiapplication systems with repetition rates of 200–1000 Hz were demonstrated at ranges up to 720 km.

Challenges. A diode-pumped ND:YAG laser that has a wide range of energy and pulse-repetition frequency outputs will need to be developed; and new, high-duty laser diode arrays will be used for high repetition rates and optical parametric oscillators for wavelength conversions. Novel cavity designs are required to allow for switchable outputs.

Milestones/Metrics.

FY2000: Demonstrate tunable laser capability at ranges of up to 20 km with <1-m resolution.

FY2001: Demonstrate repetition rates of 200–1000 Hz to support target vibration analysis and profiling.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Walter BAHR NAVAIR, PMA–231	Mr. Edward WATSON AFRL	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.09 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603203F	665A	1.2	1.4	0.0	0.0	0.0	0.0
	DTO Total	**1.2**	**1.4**	**0.0**	**0.0**	**0.0**	**0.0**

SE.13 Lightweight, Broadband, Variable-Depth Sonar

Objectives. Develop and demonstrate a surface ship-towed active sonar system employing new broadband signal generation and processing, energy-dense transducer material, automated environmental adaptability, and multifunction broadband receiver line array technologies to reliably detect and classify small, very quiet, low-Doppler, below-the-layer threat submarines in shallow littoral waters.

Payoffs. Control of the surface and undersea battlespace is an essential enabler for power projection ashore and logistic sustainment. Quiet threat submarines operating in shallow waters provide a significant threat to surface ships. Lightweight, broadband, variable-depth sonar (LBVDS) will provide surface combatants with a lightweight, broadband active sonar capability that extends platform detection capability below-the-layer providing both increased reverberation reduction and lowered false-alarm rates. The detection ranges capable with the LBVDS will reduce the visual targeting capability of threat submarines, diminishing the submarine torpedo threat. Broadband waveforms coupled with automated environmentally adaptive signal processing will mitigate environmental effects, reduce manning requirements, and produce improved performance. In FY99, a thorough, in-depth analysis of extensive sea trials that will be used to design controls, transmitter and receiver for the system was conducted.

Challenges. A broadband sonar with large time-bandwidth products (~10,000) and good spatial (~0.3-m) and Doppler (~0.3-m/s) resolution is required to suppress reverberation and channel fading effects that dominate shallow-water active acoustic returns. A variable depth sonar is required to match the signal to the sound channel occupied by the target while reducing surface reverberation (greater than 10 dB). A lightweight tow body is required to minimize ship impact issues. Automated, environmentally adaptive signal processing algorithms for maximum broadband detection/classification performance and manning reduction are needed.

Milestones/Metrics.

FY2000: Design, fabricate, and test the control, transmit, receive, and handling subsystems. Demonstrate time-bandwidth product signals of ~10,000.

FY2001: Complete system integration. Conduct two at-sea demonstrations of performance in structural runs against a low-Doppler, below-the-layer threat in shallow water. Demonstrate 90% P_d at a 7- to 10-nmi range and a one-per-day false-alarm rate.

FY2002: Conduct the second sea test in a fleet operational demonstration of performance. Conduct thorough, in-depth analyses of the two operational demonstrations. Evaluate the benefits of the technology enhancements to active sonar design.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT John BARRY, USN CNO, N863E	Mr. Ken DIAL ONR	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.13 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602314N	00000	0.8	0.6	0.8	0.0	0.0	0.0
0603747N	R2142	17.1	12.4	4.9	0.0	0.0	0.0
	DTO Total	**17.9**	**13.0**	**5.7**	**0.0**	**0.0**	**0.0**

SE.14 Multistatic Active Antisubmarine Warfare

Objectives. Develop and demonstrate a multistatic active antisubmarine warfare (ASW) capability incorporating an offboard, high-power, long-endurance, low-frequency acoustic source; an open-architecture, COTS-based onboard signal processor with target classification and shallow-water clutter rejection for coherent and impulsive sources; system performance models; and candidate multistatic ASW concepts of operation. This capability has application to existing surface ship, submarine, air, and deployed distributed sensor field receivers.

Payoffs. As threat submarines become quieter, passive sonars alone may not be capable of providing adequate detection margins; active sonars may be required to detect and localize such threats. Offboard sources (OBSs) provide a multistatic option that also avoids the beacon effects of hull-mounted or towed sources. In FY99, sea trials for algorithm development were initiated.

Challenges. The employment of an acoustic OBS requires efficient combination of a liquid metal combustor, a Stirling thermal engine and alternator, a torque-balanced flywheel, compact transducers, communications technologies, and electronic command and control in a package compatible with diverse platforms. Mechanical deployment approaches must be developed and demonstrated. Models and simulations must be employed to design the OBS, predict its performance, and develop concepts of operation for each employing platform operating in the dynamic littoral environment. Existing receivers must be integrated with processors incorporating target detection, classification, and clutter reduction algorithms to demonstrate an effective multistatic ASW system capability.

Milestones/Metrics.

FY2000: Analyze initial sea test data and construct Build 1 of multistatic ASW processor. Demonstrate autonomous OBS at sea.

FY2001: Complete OBS final design that will lead to a 15–20 dB improvement over existing passive systems; increase detection ranges by 3X–5X; increase area coverage by 10X. Conduct sea test demonstration of OBS. Demonstrate Build 2 of the multistatic ASW processor.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT John MORGAN, USN CNO, N84	Dr. Steven RAMBERG ONR 32	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.14 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602314N	00000	5.4	2.4	0.0	0.0	0.0	0.0
0603792N	R1889	5.4	5.5	0.0	0.0	0.0	0.0
	DTO Total	**10.8**	**7.9**	**0.0**	**0.0**	**0.0**	**0.0**

SE.15 Affordable High-Performance Towed Arrays

Objectives. Develop technology for improved towed arrays for tactical submarines and surface ships. Towed arrays are the most effective sensors available for passive sonar detection of threat submarines at long ranges, with emphasis on detection of low-frequency radiated noise. Analysis of current and projected threat submarine signatures indicates a need for an increase in signal-to-noise ratio gain over current towed arrays. The multiline volumetric towed array is being developed as a performance enhancement. All-optical array interrogation and telemetry technologies are being pursued to allow simplification and automation of the array wet-end manufacturing process for cost reduction in procurement and in operations as well as for improvement in reliability.

Payoffs. This DTO will improve the acoustic performance and lower the cost of towed arrays through advances such as multiline volumetric towed arrays that provide significant aperture in three dimensions. Costs of towed arrays will be lowered through use of all-optical hydrophones and telemetry and by automation of the array assembly process, reducing much of the hand-labor cost of current towed array manufacturing. Towed array costs for existing apertures will be reduced by up to 80%, making larger towed arrays more affordable. In 1999, the AAT ATD project performance goals were successfully demonstrated.

Challenges. Designs are needed for (1) multiline towed arrays that can be used with existing handling systems, (2) all-optical heading and depth sensors, and (3) optical slip rings compatible with the power budgets of optical interrogation schemes. Reliable, deployable means are needed for changing the shape of a multiline aperture for improved signal-to-noise ratio.

Milestones/Metrics.

FY2000: Demonstrate in the AAT ATD a 100-channel, 1/4-aperture, fiber-optic sensor array in a small-diameter TB 29 hose.

FY2001: Demonstrate digital receiver and automated array hose assembly with cost reduction of up to 80%.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Jim THOMPSON PEO/USW/ASTO	Mr. Scott LITTLEFIELD ONR 32	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.15 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602314N	00000	0.9	0.4	0.0	0.0	0.0	0.0
0603792N	R1889	5.1	0.0	0.0	0.0	0.0	0.0
	DTO Total	**6.0**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**

SE.19 Affordable ATR via Rapid Design, Evaluation, and Simulation

Objectives. Reduce the cost and development time for automatic target recognition (ATR) systems by facilitating the use of algorithm development tools for integrated performance evaluation, software reuse, and seamless algorithm transfer to high-power computer architectures and embedded hardware.

Payoffs. Sound research and development of viable ATR systems carries special infrastructure needs. Completion of this objective will provide a virtual distributed laboratory (VDL) that links service resources, developers, and evaluators thus greatly enhancing access to ATR development tools. Benefits will include (1) "honest broker" rigorous evaluation of ATR algorithms, (2) improved algorithms through the promotion of modular design and common interfaces, (3) robust algorithms developed in conjunction with controlled evaluations using simulations of realistic environments and operating conditions based on access to well ground-truthed data sets, (4) extensible algorithms that are able to recognize novel targets included by means of rapid target insertion based on high-fidelity signature modeling, and (5) ability to evaluate ATR performance from arrays of distributed homogenous and heterogenous sensors. The VDL will support system-level virtual prototyping for rapid and affordable ATR development. In FY99, IR scene generation at 1-Hz to 5-Hz synthetic with high fidelity to support ATR identification evaluation was demonstrated.

Challenges. The major technology barrier is the development of validated synthetic signatures and scene simulation with sufficient fidelity to support ATR development.

Milestones/Metrics.

FY2000: Demonstrate real-time, synthetic, multisensor image generation to support distributed interoperable simulations in accordance with the high-level architecture.

FY2001: Conduct a near real-time multisensor ATR and fusion algorithm demonstration and evaluation in the VDL environment against realistic operational scenario conditions with both known and novel targets.

FY2003: Demonstrate a reconnaissance-to-shooter platform rapid target acquisition and strike simulation using the VDL and the DoD battlelab simulation environments, emphasizing prototype ATR and fusion software and hardware.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Clinton WALLACE, USAF HQ ACC/DRAO	Ms. Lori WESTERKAMP AFRL/SNAS	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.19 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2003	3.2	3.9	1.8	0.0	0.0	0.0
0602709A	H95	3.8	3.4	0.0	0.0	0.0	0.0
0603203F	69DF	2.5	0.0	0.0	0.0	0.0	0.0
0603232D	P232	4.4	4.7	4.7	4.8	0.0	0.0
	DTO Total	**13.9**	**12.0**	**6.5**	**4.8**	**0.0**	**0.0**

SE.20 ATR for Reconnaissance and Surveillance

Objectives. Demonstrate automatic target recognition (ATR) algorithms for tactically meaningful reconnaissance and surveillance scenarios to find and recognize exposed targets in relatively benign backgrounds. The ATR capability will provide automated target screening and exploitation aids for the image analyst in reconnaissance or surveillance platforms or in ground stations. The effort focuses primarily on ATR for radar sensors operating in synthetic aperture radar (SAR), inverse SAR (ISAR), and high range resolution modes; airborne video sensors; and ground surveillance sensors. Targets of interest for recognition demonstrations are moving and stationary vehicles and personnel that pose a threat to forces. Template-matching and model-based ATR techniques will be demonstrated to expand the envelope of applicability of this technology to larger target sets and extended operating conditions.

Payoffs. The battlefield commander will be provided with enhanced situational awareness by fully exploiting the capability of reconnaissance and surveillance platforms. Collection asset capabilities will be greatly enhanced in the future with improved advanced SAR systems, joint surveillance target attack radar systems, and new high-altitude endurance (HAE) unmanned aerial vehicle (UAV) platforms, while effective exploitation will demand automated tools to assist in screening and interpreting the greatly expanded amounts of imagery. In FY99, detection, track, and maintenance for U2 and HAE UAV sensor systems were demonstrated.

Challenges. The robustness of ATR performance must be demonstrated in the face of real-world target and background variability.

Milestones/Metrics.

FY2000: Demonstrate for sensor systems capable of high-resolution data at a 1-ft resolution (or better) a minimum capability of 0.95 probability of correct identification (P_{id}) against up to 30 tactical mobile ground targets, with false-alarm rates of 1 per 10 km^2 in operational deployment environments other than urban. Detect and track 12 moving vehicles using video data from airborne or ground platforms, and detect and track human intruders transiting a known avenue of approach to a security area.

FY2001: Improve P_{id} against moving ground vehicles and small ships imaged from ISAR imagery to 0.9.

FY2002: With 12 video sensors, including both airborne and ground sensors, track and monitor human and vehicular activity, issuing alarms for unusual or threatening actions based on recognition of known individuals and vehicles and known patterns of activity.

FY2003: Initiate the development of form, fit, and function concepts for technology transition to operational system development.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Robert F. III DEBUSK, USA ACC/DRR	Dr. Robert HUMMEL DARPA/ISO	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.20 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602301E	ST–11	2.5	0.0	0.0	0.0	0.0	0.0
0602301E	ST–28	0.0	14.0	14.0	7.0	0.0	0.0
0603203F	69DF	1.9	2.6	0.0	0.0	0.0	0.0
0603762E	SGT–04	22.8	4.0	0.0	0.0	0.0	0.0
	DTO Total	**27.2**	**20.6**	**14.0**	**7.0**	**0.0**	**0.0**

SE.24 Common Radio Frequency Digital Modules

Objectives. Develop a family of state-of-the-art modular, multifunction, reconfigurable digital receiver modules capable of performing any mission function spanning the RF spectrum of 50 MHz to 45 GHz. These digital receiver modules consist of RF acquisition and digital processing modules. The RF acquisition modules will push digital electronics to the "front end" by acquiring data as close to the aperture as feasible, while the digital processing modules will sustain increased performance in processing, bandwidth, and latency. The efforts build on the $100 million DARPA investment in the areas of very high sample rate analog-to-digital converters (ADCs), high-performance digital signal processors, and scalable computing systems in order to significantly improve the methods by which RF signals are acquired or transmitted and processed.

Payoffs. The efforts will increase the multimission capabilities of platforms while minimizing acquisition and life-cycle costs. By developing a set of common modules that can be used to upgrade existing systems or to create new systems that receive and process RF signals, the programs will provide a significant reduction in size, weight, power, support costs, and training. The Navy's Advanced Common Electronic Module program will initially perform electronic support measures and radio receiver demonstration tests in a laboratory, and will be followed by flight testing in an SH–60R helicopter. The Air Force's Modular Digital RF System will demonstrate a radar receiver application. In FY99, module assembly, fabrication, integration and laboratory tests were completed.

Challenges. Technical barriers include the integration of advanced electronic components including the integration of very high sample rate ADCs in a densely packaged multichip module. Another challenge is to achieve full functional performance while maintaining the "generic-ness" required to build multiple systems.

Milestones/Metrics.

FY2000: SH–60R EW and radio receiver flight demonstration.

FY2001: Four-channel multimode radar receiver demonstration.

FY2002: RF front-end dual-use demonstration.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT R. KOLLMORGEM, USN NAVAIR, PMA–299	Mr. John KINZER ONR 351	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.24 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603217N	R0447	3.5	0.0	0.0	0.0	0.0	0.0
0603253F	2735	1.1	1.5	0.7	0.0	0.0	0.0
	DTO Total	**4.6**	**1.5**	**0.7**	**0.0**	**0.0**	**0.0**

SE.33 Advanced Focal Plane Array Technology

Objectives. Using cooled and uncooled arrays, increase range and target acquisition/discrimination by improving the noise-equivalent delta temperature (NEDT) of uncooled sensors and by fusing two or more bands of cooled detectors.

Payoffs. Uncooled focal plane arrays (FPAs) are low in cost, weight, and power consumption. Consequently, applications in the low-to-medium performance military market will proliferate if the sensitivity and resolution can be improved. Fusing two or more bands of cooled high-performance FPAs will result in a sensor with improved detection range and an order of magnitude reduction in false-alarm rates. Use of sophisticated growth and fabrication techniques will increase the functionality of FPAs and make them more affordable. This resulted in a 2X increase in effective detection range. In FY99, NEDT of 0.01 K for uncooled FPA with 30-µm pixels were demonstrated.

Challenges. The major challenges for the uncooled sensor are the reduction in thermal isolation and the increase in responsivity of uncooled detector material. The major challenges for the high-performance cooled arrays are to grow the substrates monolithically on silicon and develop on-chip readouts to pre-process and fuse the large data rates.

Milestones/Metrics.

FY2000: Complete flexible manufacturing technology for HgCdTe for burst-mode operation. Demonstrate 1,024 x 1,024 LWIR FPA. Demonstrate 640 x 480 uncooled FPA with less than 0.05 milli-kelvin/1 milli-pixel.

FY2001: Demonstrate two-color, large format HgCdTe FPAs with adaptive readout circuits. Demonstrate 25-gram uncooled imaging sensors with performance acceptable for micro-air vehicles.

FY2002: Demonstrate 320 x 240, 15-micrometer pixel with sensitivity less than 10 milli-kelvin.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. R. HABAYEB NAVAIR, 4.OT	Dr. Stuart HORN USA/NVESD	Dr. Susan TURNBACH ODUSD(S&T)/SS
Mr. C. THORTON USA/DBBL		

SE.33 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602709A	H95	4.0	4.1	0.0	0.0	0.0	0.0
0603739E	MT–03	10.7	12.0	7.0	0.0	0.0	0.0
	DTO Total	**14.7**	**16.1**	**7.0**	**0.0**	**0.0**	**0.0**

SE.35 Optical Processing and Interconnects

Objectives. Develop radically new optical interconnect technologies that provide terabit-per-second throughput between chips, boards, and processors. The goal is to achieve tera-operations-per-second processing in a massively parallel optoelectronic processor that is small in size and low in power consumption.

Payoffs. High-speed signal processing is driven by the operational realities of increasing jammer densities against C^4I assets, low-observable target surveillance, and the requirement to manage large intelligence databases. Performance limits of conventional electronic approaches to air and ground surveillance are stressed by low-observable threats, sophisticated electronic countermeasures, and increased target densities, and complexity of the modern battlefield, all of which make high processing speeds essential. Hybrid or all-optical techniques provide solutions to the processing bottleneck at reasonable levels of cost, power consumption, and volume. In FY99, an optical backplane using polymer fiber with less than 10-dB losses and 35-GHz bandwidth was demonstrated.

Challenges. Major challenges are developing large (1,000/cm^2) “smart” pixel and detector arrays. Optoelectronic integration to reduce size and cost is a major challenge in the implementation of parallel interconnects and processors.

Milestones/Metrics.

FY2000: Demonstrate a 1-Gbps free-space optical interconnect.

FY2001: Demonstrate STAP using optical backplane.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. L. FENSTERMACHER HQ ACC/DRSL	Dr. Don HANSON AFRL/SN	Dr. Susan TURNBACH ODUSD(S&T)/SS
Mr. M. TINNEY USAF/AIA		

SE.35 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2002	0.0	0.8	0.0	0.0	0.0	0.0
0602204F	6096	0.6	0.0	0.0	0.0	0.0	0.0
0602712E	MPT–02	19.6	8.0	0.0	0.0	0.0	0.0
0603726F	2810	1.1	0.0	0.0	0.0	0.0	0.0
	DTO Total	**21.3**	**8.8**	**0.0**	**0.0**	**0.0**	**0.0**

SE.36 Photonics for Control and Processing of Radio Frequency Signals

Objectives. Develop photonics technology to route, control, and process RF and microwave signals in military applications, including photonic components and systems for control of phased-array antennas and distribution of RF signals.

Payoffs. Conventional phased arrays are limited to 10% bandwidth because the phase shifters are frequency-dependent, resulting in beam “squint” for broadband signals. Fiber optics provide true time delay, which eliminates this problem. The antenna beam control technology will result in greater than 1,000X improvement in bandwidth capability for ISR sensors and substantial cost savings due to lighter, smaller (by a factor of 100), and less complex assemblies. Beam control provides antijam, wideband, multimode phased-array antennas for such applications as global positioning systems and unmanned aerial vehicles. Fiber optics also enables the remoting of antennas and emitters over kilometer distances, whereas coaxial links are limited to a few hundred feet by inadequate frequency response and dispersion. In FY99, a 1- to 100-GHz optical radio frequency synthesizer with -90 dBc phase noise, and modulators and detectors for 30–300 GHz were demonstrated. In addition, a lithium niobate modulator and high-current photodetectors for low-loss satellite links were developed.

Challenges. Optical fiber and planar waveguides provide a broadband, low-loss transmission medium for long, distortionless communications links for emitter remote operation and true time delay for optical beamforming. Most applications have stringent dynamic range requirements; consequently, the principal challenge lies in developing the components, including low-relative intensity noise (less than 150 dB/Hz) laser diode sources; fast, power-tolerant (100 mW) detectors; linearized modulators; and low insertion loss (less than 1 dB) switches to meet the requirements.

Milestones/Metrics.

FY2002: Demonstrate an optically controlled phased array for SATCOM. Demonstrate optically controlled phased-array receiver for shipboard applications (2–18 GHz).

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. John MONTGOMERY NRL	Dr. Don HANSON AFRL/SN	Dr. Susan TURNBACH ODUSD(S&T)/SS
Mr. M. TINNEY USAF/AIA		

SE.36 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2002	0.0	0.8	0.0	0.0	0.0	0.0
0602204F	6096	0.6	0.0	0.0	0.0	0.0	0.0
0602234N	00000	0.4	0.0	0.0	0.0	0.0	0.0
0603203F	69CK	0.2	0.0	0.0	0.0	0.0	0.0
0603726F	2863	1.8	0.0	0.0	0.0	0.0	0.0
0603739E	MT–04	13.2	11.5	9.0	0.0	0.0	0.0
	DTO Total	**16.2**	**12.3**	**9.0**	**0.0**	**0.0**	**0.0**

SE.37 High-Density, Radiation-Resistant Microelectronics

Objectives. Develop high-performance, extremely dense, radiation-hardened microelectronics that are key to continued U.S. domination of battlefield intelligence, surveillance, and communications as well as joint theater missile defense. Space applications, which presently dominate requirements for radiation-hardened microelectronics, need to operate reliably after exposure to natural and nuclear radiation.

Payoffs. Strategic missiles (Minuteman and Trident), BMDO interceptor systems, and satellites such as Milstar, UHF Follow-On, GPS–IIF, DSP, SBIRS–High, SBIRS–Low, Space-Based Laser, Space-Based Radar, and Advanced EHF require radiation-hardened microelectronics. This DTO provides these space and strategic systems with timely access to key microelectronic technologies through advanced processing and technology development. The technologies developed provide significant reductions in weight, size, and power while simultaneously increasing performance. During FY99, fully functional, 4-million-bit, static random-access memories (SRAMs) and 32-bit microprocessors were successfully fabricated. These radiation-hard high-performance circuits represent the densest radiation-hard microcircuit ever produced having over 30 million transistors with effective gate lengths of 0.25 µm and operated with a record 20-ns access time. In addition, radiation-hard digital signal processors based on commercial designs (C30/40 and 21020) were fabricated.

Challenges. Challenges include (1) developing at private-sector foundries affordable process, design, and layout of microelectronics to enable them to survive in the unique radiation environments required by DoD systems; (2) applying electronic design automation tools in conjunction with high-volume commercial processes to close the gap between radiation-hardened and commercial devices; and (3) reducing piece/part costs to DoD customers by increasing commercial purchases and adapting commercial technologies.

Milestones/Metrics.

FY2000: Demonstrate a rad-hard 4-Mb SRAM with 16X density and 2X speed improvement; demonstrate complementary GaAs process through power MOSFET for 10% improved dc/dc converter efficiency over CMOS; develop process for rad-hard 1-Mb nonvolatile memory; develop dc/dc power converter at 200 W/lb; and demonstrate architecture through hardware-in-the-loop and software simulator testbeds to reduce system validation costs by 50%.

FY2001: Develop submicron 4-Mb memories; demonstrate prototype single-chip, 32-bit data processor, rad-hard 4-M gate arrays to support 4X weight reduction in advanced EHF satellite weight; develop rad-tolerant commercial 0.18-µm CMOS to support 8-M gate array with 2X speed and density improvements; and demonstrate low-cost process for 1-Mb nonvolatile memory with 100X increase in speed over flash memory.

FY2002: Demonstrate rad-hard, PowerPC-like data processor at 300 MIPS; demonstrate rad-hard 0.25-µm CMOS/SOI fabrication process and demonstrate 4-M gate arrays for 2X speed and density improvements; and demonstrate rad-hard by design 1,024-point FFT with 10X improvement in speed and power reduction.

FY2003: Demonstrate feasibility of artificial neural network computer for space applications and demonstrate rad-hard DSP core implementations to achieve TFLOP performance and 10X processing speed improvement.

FY2004: Demonstrate rad-hard system-on-a-chip for 100X part count reduction and demonstrate rad-hard analog memory with 2% readout accuracy.

FY2005: Demonstrate a rad-hard, very deep submicron mixed-signal design automation system to support system-on-chip designs with 10X reduction in design costs and time, and demonstrate a rad-hard, prototype 16-Mb SRAM with 64X density improvement and 4X speed improvement.

Customer POC

Ms. Karen BASANY
SMC/MTA

Service/Agency POC

Maj Steve CLIATT, USAF
SAF/AQRT

Mr. Erwin MYRICK
BMDO/TOS

Dr. Les PALKUTI
DTRA/NSSE

Dr. Harold SCHONE, USAF
AFRL/VSSE

USD(A&T) POC

Dr. Susan TURNBACH
ODUSD(S&T)/SS

SE.37 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602601F	4846	0.0	3.6	4.1	0.0	0.0	0.0
0602601F	8809	3.0	0.0	0.0	0.0	0.0	0.0
0602715BR	AF	4.6	0.0	0.0	0.0	0.0	0.0
0602715BR	BH	0.0	7.3	5.6	6.3	6.3	7.6
0603401F	2181	9.1	8.1	9.1	0.0	0.0	0.0
	DTO Total	**16.7**	**19.0**	**18.8**	**6.3**	**6.3**	**7.6**

SE.37 Non-S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603871C	2402	2.6	3.0	0.0	0.0	0.0	0.0
	DTO Total	**2.6**	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**

SE.38 Microelectromechanical Systems

Objectives. Develop microelectromechanical systems (MEMS) components that are expected to improve the size, weight, cost, and assembly complexity of existing applications areas such as positioning systems and inertial guidance systems by an order of magnitude. MEMS sensor and actuator arrays are expected to increase performance, capability, and lifetime of major systems such as communications and military platforms.

Payoffs. This DTO will merge sensing, computation, and actuating to realize new systems and strategies for both perceiving and controlling weapon systems, processes, and battlespace environments. MEMS promises to allow new programs started in the near term to deploy accelerometer and inertial guidance functions an order of magnitude lower in size, weight, cost, and assembly complexity than alternative technologies. In FY99, high-density data storage of 40X greater capacity, integration densities of 1,000 components/cm^2, and microactuators for airfoils were demonstrated.

Challenges. Key near-term challenges are to develop the basic materials, devices, and processes to integrate mechanical components with sensing, computing, and actuating components at a density of 1,000 mechanical components/cm^2 with on-chip microelectronics of at least 10,000 transistors. A basic support for this technology area will be the development of an infrastructure that not only can build single prototype components at increasing densities and complexities, but also lays the foundation for establishing a reliable, assured industrial base to supply emerging defense applications.

Milestones/Metrics.

FY2000: Demonstrate MEMS devices for RF applications, filters, and switches.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Viktor JONKOFF JSF	Dr. A. P. PISANO DARPA/ETO	Dr. Susan TURNBACH ODUSD(S&T)/SS

SE.38 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603739E	MT–12	28.7	0.0	0.0	0.0	0.0	0.0
	DTO Total	**28.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

SE.39 Wide-Bandgap Electronic Materials Technology

Objectives. Develop high-performance, wide-bandgap semiconductor materials for compact transmitters used in military-essential RF radars, communications and electronic warfare sensors, and laser sources and detectors. Goals include development of lattice-matched substrates for silicon carbide (SiC) and gallium nitride (GaN) devices and methods to produce uniform semi-insulating and doped films.

Payoffs. Attainment of SiC goals will enable production of high-power switches operating at 1,000 V and at current densities exceeding 1,000 A/cm^2. The resultant power density exceeds that of silicon by a factor of five, achieving considerable size and weight reduction of power supplies. Attainment of the III–N goals will allow high-power RF performance and development of long-life lasers. In FY99, a commercially viable SiC epitaxy process and a means to synthesize 1-in diameter substrates lattice matched to GaN were demonstrated.

Challenges. SiC RF power device production requires a 3-in substrate diameter. Semi-insulating, lattice-matched substrates are required for planar RF device technology. Defect levels must be reduced to avoid compensation and to improve dielectric strength. Viable lattice-matched substrates are needed for GaN. Defect densities in GaN are still orders of magnitude too high for long-lived, HF (30 GHz) RF devices. No shallow p-type dopant exists for SiC or GaN.

Milestones/Metrics.

FY2000: Demonstrate materials/processing quality commensurate with power device structures with less than 10% performance variation across wafer.

FY2001: Transfer to manufacturing 3-in diameter wafers of 4H SiC with doping concentration variation less than 10% and micropipe density less than 5/cm^2.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Viktor JONKOFF JSF	Dr. Ben SHANABROOK NRL	Dr. Susan TURNBACH ODUSD(S&T)/SS

SE.39 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2002	0.1	0.0	0.0	0.0	0.0	0.0
0602234N	00000	0.3	0.3	0.0	0.0	0.0	0.0
	DTO Total	**0.4**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**

SE.43 Energy Conversion/Power Generation

Objectives. Demonstrate safe, small, lightweight, low-cost, environmentally compatible power sources with higher power and energy densities and improved flexible charging systems.

Payoffs. Payoffs include lower costs; lighter burden for the warrior; longer periods of autonomous operation; more user-friendly systems; smaller, lighter systems with higher efficiencies; and reduced thermal signature. In FY99, a universal vehicle-mounted field charger, a 100-W fuel-cell-powered continuous duty silent charger, and a fuel-cell battery were demonstrated.

Challenges. Several barriers need to be overcome: increasing energy density while maximizing safety; providing logistically acceptable charging systems; attaining good low-temperature performance; developing autonomous charging systems for small-unit operations; minimizing overall system size and weight; and improving efficiency of systems through the use of power electronics that suppress acoustic and thermal signatures.

Milestones/Metrics.

FY2000: Demonstrate (1) zinc-air, low-cost ($0.10/Whr) primary battery for training, battery recharging, and remote operations; (2) safer, higher-energy (100 Whr/kg) rechargeable lithium-ion batteries; (3) liquid-fueled fuel cell system providing 2,000 Whr/kg of fuel; and (4) diesel-fueled 500-W thermophotovoltaic portable power source with 13% efficiency.

FY2001: Demonstrate pouch primary battery with 50% more energy (250 Whr/kg) in flexible and conformal packaging and polymer rechargeable batteries capable of 120 Whr/kg.

FY2002: Develop nonflammable electrolyte for rechargeable batteries. Demonstrate GEN–II Smart Charging Cable and Charger-on-the-Move.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Tom NYCZ USA/CECOM	Mr. Rob SAUNDERS SARD/TT	Dr. Susan TURNBACH ODUSD(S&T)/SS

SE.43 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602705A	H11	1.0	0.9	1.3	0.0	0.0	0.0
0602705A	H94	0.5	0.6	0.6	0.0	0.0	0.0
0602712E	MPT–01	1.8	0.0	0.0	0.0	0.0	0.0
	DTO Total	**3.3**	**1.5**	**1.9**	**0.0**	**0.0**	**0.0**

SE.44 Power Control and Distribution

Objectives. Develop, demonstrate, and transition high-density, high-efficiency power conversion systems for microelectronics applications in the 30-W to 100-W regime that will advance the architectures, topologies, power devices and components, and control electronics. These devices (converters) must meet the power quality, density, and voltage requirements for the next-generation digital or analog military subsystems and power electronic building blocks (PEBBs) module applications. This DTO will also develop integrated high-density-efficiency power supplies, solid-state switching devices (power ICs), and new materials and packaging technologies that combine low-profile passive components, sensors, circuit leads, high-density interconnections, and thermally efficient substrates.

Payoffs. This DTO will provide more performance and efficient power supplies that conform to system requirements while providing lower-cost power components and devices through standardization and common architecture. Self-configuring power modules will provide a single subsystem for multiple applications. In FY99, advanced power circuit designs that lead to a 300% improvement in power density, and a brassboard version of multifunction 30-W power supply were demonstrated.

Challenges. The challenges include the simultaneous development and advancement of microelectronics component power supply technologies while reducing the system cost. Power devices and microelectronics controls need to be integrated for reduced footprint, cost, and control PEBB functions. Development of 1,500-V isolation from PEBB module operation, composite substrates with thin film magnetic material and dielectrics materials, algorithms for self-configuring input/output, electromagnetic interference resistance to PEBB and like environments, and power density are factors that must be considered.

Milestones/Metrics.

FY2000: Demonstrate 30- to 100-MHz GaAs heterojunction bipolar transistors for 100-W radar power supply applications. Transfer multifunction 30-W power supply technology to power supply commercial manufacturer.

FY2001: Select candidate device materials and structures for 100-MHz power switches.

FY2002: Fabricate and test power devices up to 100-MHz switching rates. Demonstrate power devices in a high-frequency resonant power topology using high-density interconnect packaging approaches.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LCDR Tim MCCOY, USN NAVSEA, 03Z	Dr. Ingham MACK ONR 31	Dr. Susan TURNBACH ODUSD(S&T)/SS

SE.44 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602121N	00000	0.3	0.3	0.0	0.0	0.0	0.0
0602204F	2002	0.0	0.5	0.4	0.0	0.0	0.0
0602204F	6096	0.3	0.0	0.0	0.0	0.0	0.0
0602234N	00000	0.3	0.3	0.0	0.0	0.0	0.0
	DTO Total	**0.9**	**1.1**	**0.4**	**0.0**	**0.0**	**0.0**

SE.57 Analog-to-Digital Converter

Objectives. Develop analog-to-digital converters (ADCs) and related components to demonstrate digital receivers targeting military radar, electronic warfare (EW), and C^4I systems, with the initial demonstrations in digital receivers and EW radar (E2C and AWACS). The ADC is the key component for managing all sensor data in a wide range of areas (e.g., space-based electronics, antisubmarine warfare, smart weapons, C^4I). Some specific impacts of these developments and demonstrations are a 16X improvement over current capabilities in over-the-horizon detection, detection of a submarine periscope in clutter, and precision tracking of horizon sea-skimming cruise missiles in clutter.

Payoffs. The application of advanced ADCs in the building of digital receivers will enable substantial improvements in key military applications. A critical advantage of digital receivers will be agility, allowing a single receiver to support multiple applications over a broad range of frequencies and bandwidths. Elimination of analog circuitry will yield substantial improvements in system reliability, accuracy, and repeatability. Finally, elimination of bulky and costly down-conversion stages will reduce the size, weight, and cost of front ends for receivers. Programs that are expected to employ these technologies include the F–22, Comanche, JSF, Aegis SPY 1–D, F–15 APG–63 upgrade, F–18 APG–73 upgrade, E2C APS–145 surveillance radar, and B–2 APQ–181 radar. In FY97, an 8-bit/3-Gsps and a 12-bit/100-Msps GaAs heterojunction bipolar transistor (HBT) ADC was demonstrated. In FY98, a 10-bit/1-Gsps GaAs HBT ADC was demonstrated. In FY99, a 4-bit/10-Gsps ADC in complimentary metal oxide semiconductor (CMOS)/silicon-on-silicon (SOS) was demonstrated.

Challenges. The challenges include developing high-speed, high-resolution ADCs that require very high-speed semiconductor devices with very low noise, innovative circuit design, accurate models for high-speed analog devices, and advanced packaging to overcome the performance limiting factors of thermal noise, clock jitter, and device nonlinearities. The capabilities of many defense systems are currently limited by the performance of their ADCs.

Milestones/Metrics.

FY2000: InP/InGaAs BiFET devices with Ft~200 GHz; 4-bit to 5-bit/20-Gsps ADC in CMOS/SOS; 14-bit/60-MHz instantaneous bandwidth ADC demonstration; full 16-bit to 18-bit/2-ksps to 100-ksps/1-mW ADC for unattended deployable sonar surveillance applications; design scaled InP HBT bandpass modulator with center frequency of 10 GHz.

Customer POC

Mr. Viktor JONKOFF
JSF

Capt Wesley KREMER, USAF
ACC/DRA

Service/Agency POC

Mr. Tim KEMERLEY
AFRL/SND

USD(A&T) POC

Dr. Susan TURNBACH
ODUSD(S&T)/SS

SE.57 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2000	0.7	0.0	0.0	0.0	0.0	0.0
0602234N	00000	0.2	0.0	0.0	0.0	0.0	0.0
0602712E	MPT–02	2.0	0.0	0.0	0.0	0.0	0.0
0603203F	69CK	0.2	0.0	0.0	0.0	0.0	0.0
	DTO Total	**3.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

SE.58 Lookdown Bistatic Technology

Objectives. Develop and demonstrate passive (bistatic) airborne/spaceborne lookdown surveillance and target identification technologies; and initiate their transition to operational assets such as the unmanned aerial vehicle (UAV) wing (Tier–2 and –3) for which ASC/RA has mission architecture responsibilities, to the reconnaissance assets such as Rivet Joint of Det–2 645th MATS, and for mission enhancements for the AWACS wing in support of its planning system project office, namely ESC/AWO. Included in this development are bistatic imaging capabilities such as bistatic synthetic aperture radar (BISAR), and adaptive interference cancellation techniques known as bistatic space–time adaptive processing (BISTAP).

Payoffs. The technical approach is based on the airborne bistatic technology demonstrated and matured by Rome Laboratory combined with the plan to scale this technology to the mission applications/environments addressed respectively by ASC, Det–2, and ESC/AWO. Significant payoffs will be directly realized, such as covert self-protection, long-range surveillance and target ID, augmented operating modes that enhance mission operations and performances, and quick transition into operational assets producing mission enhancements while avoiding the disruption of their standard performance. This directly supports the warfighter in the field who is jointly serviced by TR–1 assets, Rivet Joint, and AWACS without disrupting these warfighter service functions and enhancing mission capabilities in the short term.

Challenges. The technical challenges are lookdown clutter cancellation and management when bistatically exploiting noncooperative, nonoptimized, multiple illuminator sources and their waveforms. This includes the adaptive rejection of jammer-like signals, operating in high-signal-density environments and their associable interference in wartime conditions, and the constraints associable with operational platforms.

Milestones/Metrics.

FY2000: Demonstrate combined coherent, noncooperative bistatic surveillance plus target imaging routinely in operational environments of moving lookdown clutter and multiple, complex ambient interferes. Classification repeatability within 95%.

FY2001: Conduct tests on board operational assets such as selected Tier UAV and Rivet Joint. Detection/tracking performance to exceed 93%, SNR 13 dB nominal.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Joseph WORRELL 645th MATS/Det–2	Mr. Robert OGRODNIK AFRL/OCSM	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.58 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	7622	0.0	0.9	0.0	0.0	0.0	0.0
0602702F	4506	0.8	0.0	0.0	0.0	0.0	0.0
	DTO Total	**0.8**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**

SE.58 Non-S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603178F	1697	1.2	0.6	0.0	0.0	0.0	0.0
0603889F	2787	2.0	0.5	0.0	0.0	0.0	0.0
	DTO Total	**3.2**	**1.1**	**0.0**	**0.0**	**0.0**	**0.0**

SE.59 Low-Light-Level Imaging Sensors

Objectives. Demonstrate solid-state visible, near-infrared (NIR), and short-wavelength infrared (SWIR) sensors for a broad range of night vision applications, including pilotage and navigation, weapon sights, missiles guidance, surveillance, and targeting. The warfighter requires a means to amplify the available illumination in order to operate effectively at night.

Payoffs. The warfighter currently uses image intensifier (I^2) tubes often used in unity-magnification and direct-view night vision goggles (NVGs) mounted on the head. I^2 tubes are also used to amplify light onto charge-coupled devices (CCDs), which provide a video output capable of being enhanced, fused with other imagery, mixed with symbology, transmitted, and recorded. The payoff is a high-resolution, solid-state alternative for I^2. In addition, an electronic readout located off the head (e.g., in a head-steered turret or other remote position) will facilitate flexible integration of the individual soldier into the digital battlefield. This will increase opportunities for enhanced situational awareness. An RS–170-compatible, low-light-level CCD camera capable of useful operation at light levels below 10^{-2} lux (reflectance) has been demonstrated. In FY99, an SWIR solid-state device was demonstrated at these light levels.

Challenges. Technical barriers include the development of alternative photon sensing materials, such as Si, InGaAs, and wide-bandgap HgCdTe, that have the potential for significantly improving performance under extremely low-brightness and -contrast conditions. Additionally, the ability to develop solid-state visible, NIR, and SWIR sensors for a broad range of night vision applications will be a technology advancement in the warfighters ability to operate effectively at night.

Milestones/Metrics.

FY2000: Develop and demonstrate a low-cost, lightweight, low-light-level camera for a miniature UAV.

FY2001: Develop and demonstrate an RS–343-compatible NIR or SWIR array suitable for rotary-wing pilotage application.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Mack FAULK USA/NVESD	Mr. Bill MARKEY USA/NVESD	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.59 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602232N	00000	0.8	0.0	0.0	0.0	0.0	0.0
0602709A	H95	4.7	4.6	0.0	0.0	0.0	0.0
	DTO Total	**5.5**	**4.6**	**0.0**	**0.0**	**0.0**	**0.0**

SE.61 Multiphenomenology Sensor Fusion for ATR and Tracking

Objectives. Provide multisensor fusion algorithms for automated target recognition (ATR) of land targets for multiple warfighter platform applications. The sensors to be fused include radar, IR, laser, EO, multispectral imaging, hyperspectral imaging, and electronic signals sensors. This DTO emphasizes cross-phenomenology fusion (e.g., radar with IR or EO, IR with laser, radar with electronic signals) algorithm development. The fusion algorithms will be demonstrated in prototype form on laboratory computing workstations and high-performance computing assets.

Payoffs. Successful completion of this program will provide improved ATR and tracking algorithms to accomplish robust search, tracking, and targeting performance under realistic battlefield scenario conditions. Sensor fusion aids for image analysts in intelligence, surveillance, and reconnaissance ground stations will provide improved location, recognition, and tracking of targets in realistic wartime deployment scenarios. Sensor fusion aids for shooters in airborne or ground platforms will provide more efficient target association and recognition for acquiring and killing mobile targets under operational deployment conditions. Sensor fusion for terminal guidance in unaided tactical or conventional missiles will provide more reliable selection of missile aimpoints under realistic battlefield conditions. In FY99, reduced time for target identification from minutes to seconds using computer automation was demonstrated.

Challenges. The major barriers to overcome are (1) insufficient information from a single phenomenology sensor to adequately discriminate targets from backgrounds in difficult scenario conditions such as foliage, weather, and enemy camouflage, concealment, and deception; (2) insufficient timelines for manually comparing multiple phenomenology products on CRT displays in the targeting process; and (3) insufficient accuracies of target locations reports as determined by single sensors.

Milestones/Metrics.

FY2000: Reduce false-alarm rate (FAR) to 0.2 while maintaining P_d of 0.85 by fusing dual-band FLIR and LADAR imagery.

FY2001: Reduce FAR to 0.1 per frame while maintaining P_d 0.8 for target acquisition and recognition performance by fusing SAR and FLIR imaging sensor information in a fighter cockpit.

FY2003: P_d 0.9 and P_r 0.8 for FAR less than 0.01 for multisensor fusion of SAR, EO multispectral, and SIGINT in reconnaissance ground stations; maintain tracks of vehicle groupings through multiple platforms and missions.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Clinton WALLACE, USAF HQ ACC/DRAO	Mr. Lloyd GOODWON AFRL/SNAA	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.61 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602120A	H16	0.6	0.0	0.0	0.0	0.0	0.0
0602204F	6095	1.9	1.9	2.4	1.8	0.0	0.0
0603203F	69DF	1.5	2.1	3.5	4.4	0.0	0.0
0603253F	666A	1.5	3.0	3.1	3.3	0.0	0.0
	DTO Total	**5.5**	**7.0**	**9.0**	**9.5**	**0.0**	**0.0**

SE.62 LADAR ATR for Conventional Weapons

Objectives. Provide laser radar (LADAR) automatic target recognition (ATR) capabilities in all mission areas of conventional guided weapons including the span of applications related to missiles, bombs, submunitions, and projectiles. Primary emphasis is the development of algorithmic methodologies necessary to detect, classify, recognize, identify, and characterize targets that are appropriate for conventional weapon scenarios. Secondary emphasis is directed toward investigating relationships between ATR functional components and overall system performance for characterizing algorithm sensitivity and extensibility.

Payoffs. This DTO provides for effective weapon engagement against a widely dispersed threat within the context of the digital battlefield. It will demonstrate extended range capabilities for lock-on after launch, which will play a crucial role in future soldier/weapon survivability. Successful completion of this program will provide algorithmic methodologies necessary to develop LADAR ATR capabilities for conventional weapons to accurately and predictably locate, acquire, track, attack, and destroy a given target. Proven methodologies will provide essential ATR components that can be combined to form prototype algorithms for LADAR sensors in conjunction with various weapon applications (e.g., LOCAAS, SSB, Warrior). Laboratory demonstrations of prototype algorithms will determine relationships between ATR algorithm performance and system characteristics such as sensor parameters, target sets, and mission scenarios; and will provide insight into processor requirements for weapons in terms of hardware packaging versus available volume, power/throughput requirements, heat dissipation, and cost. Relationships between ATR components and system performance will provide system-level performance criteria necessary to characterize algorithm sensitivity and extensibility for different applications. This, in turn, will provide the capability to optimize or configure LADAR ATR algorithms for a given mission scenario, thus aiding in preflight mission planning or inflight weapon preparation. In FY99, LADAR ATR technologies having predictable performance for in-flight weapon systems with P_{acq} 80% and feature resolution less than 0.064 m^3 were demonstrated.

Challenges. The major technology challenge in developing algorithmic methodologies is to meet the diverse requirements of conventional weapon systems while providing robust functionality within their demanding physical environments. Performance metrics must be accomplished before the realization of optimized/configurable LADAR ATR algorithms can be achieved.

Milestones/Metrics.

FY2000: Quantify confidence in ATR performance.

FY2001: Develop an articulated target algorithm for a submunition weapon with P_{id} = 85%; characterize clutter for LADAR ATR.

FY2002: Identify performance domains critical to LADAR ATR.

FY2003: Automate LADAR ATR predictability to less than 5 min.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Edmund ANDERSON PEO/CU	Mr. Martin F. WEHLING AFRL/MNAG	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.62 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602111N	00000	1.2	0.8	0.0	0.0	0.0	0.0
0602602F	2068	1.2	0.0	0.0	0.0	0.0	0.0
0602602F	2502	0.0	1.4	1.4	1.5	1.4	1.4
	DTO Total	**2.4**	**2.2**	**1.4**	**1.5**	**1.4**	**1.4**

SE.63 Digital Beamforming Antenna Technology

Objectives. Build and test critical subsystems and components of digital beamforming (DBF) array antenna systems with the ultimate goal of solving key deficiencies in existing Air Force and Navy radar systems. Component technology from microwave and analog front-end technology, other DARPA programs, existing DTOs (e.g., SE.57, IS.33) will be integrated.

Payoffs. Present radar capabilities for detection and tracking of multiple targets in the presence of interference (clutter, jamming, etc.) are inadequate against the low-observable (LO) technology of the future. This capability is offered with a digital beamforming receive array. A second need is for a multifunction radar, using wideband-shared multifunction apertures, to use digital beamforming systems with frequency-selective front ends for receive and transmit operations. In FY99, advanced algorithms for space–time adaptive processing (STAP) and failure correction on a receive-only testbed were completed and a lightweight subarray design was finalized. A miniaturization of brassboard transmit/receive (T/R) module was also completed.

Challenges. For the receive-only system, the challenges are in developing advanced algorithms for STAP of multiple beams with jammer and platform/terrain clutter suppression, and array failure correction; and in the design and development of lightweight subarrays for mobile platforms. For the multifunction system, T/R modules are needed for digital beamforming functionality.

Milestones/Metrics.

FY2000: Build and test lightweight DBF subarray.

FY2001: Complete algorithms for STAP. Test failure correction on receive-only system.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. A. BUDREAU ESC/AWO	Mr. Bob MAILLOUX AFRL	Dr. Susan TURNBACH ODUSD(S&T)/SS

SE.63 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	7622	0.9	1.0	0.0	0.0	0.0	0.0
	DTO Total	**0.9**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**

SE.64 Millimeter-Wave Gyro-Amplifiers

Objectives. Develop efficient, high-power, high-gain, wide-bandwidth amplifiers and the associated RF driving sources and high-power components for defense applications above 30 GHz. The millimeter-wave (MMW) amplifier technology is intended to support current and future high-performance radar systems.

Payoffs. MMW systems offer order-of-magnitude performance improvements for high-resolution fire control, target identification, and imaging radars. Benefits include enhanced angular resolution, improved range resolution, and secure operation provided by high-gain, narrow-beam antennas with corresponding applications including inverse synthetic aperture radar classification of aircraft, detection of low-observable targets, and improved command guidance. Critical MMW components addressed as part of this effort include high-power duplexers, low-loss rotary joints, polarizers, and electronically scanned antennas.

Challenges. The primary technical challenges for this development are to surpass the bandwidth and power capabilities of existing MMW amplifiers while maintaining high efficiencies and compact volumes. The approach is to increase the bandwidth and power of existing traveling-wave-tube driving sources through the use of improved RF circuits and electron beam confinement techniques; and increase the power bandwidth product of the current state of the art in high-power amplifier technology by one or more orders of magnitude through the development of fast-wave devices such as gyroklystrons and gyrotwystrons. These approaches exploit ongoing advances in modeling and simulation tools as well as in materials and materials processing.

Milestones/Metrics.

FY2000: Demonstrate W-band (94-GHz) gyro-amplifier with 100-kW peak power, 10% duty, and 1000-MHz bandwidth.

FY2001: Demonstrate 94-GHz gyro-amplifier with 100-kW peak power, 10% duty, high pulse rate, and 3-GHz bandwidth.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Frank RUCKY NSWC/DD	Dr. Ingham MACK ONR 31	Dr. Susan TURNBACH ODUSD(S&T)/SS

SE.64 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602234N	00000	6.2	5.7	0.0	0.0	0.0	0.0
	DTO Total	**6.2**	**5.7**	**0.0**	**0.0**	**0.0**	**0.0**

SE.65 Long-Wavelength and Multispectral, Large-Area, Staring Focal Plane Arrays

Objectives. Develop long-wavelength and multispectral, large-area, staring IR focal plane arrays for ground and space applications. Mercury-cadmium-telluride (HgCdTe) focal plane arrays (FPAs) as large as 2,048 x 2,048 for terrestrial applications and radiation-hardened versions as large as 256 x 256 for use in space will be built. The terrestrial FPAs will have an operating temperature of 120 K or higher and will have flexibility to change frame rates from 30 Hz to 480 Hz. These FPAs will also have an integrated laser receiver to provide functions such as target profiling.

Payoffs. This new class of IR sensor will provide the warfighter with major improvements in the location and identification of forces, location and classification of missile launches, location of land mines, points of origin of bullets and munitions, search and track, and discrimination capability to extract targets from clutter. In FY99, a Si/HgCdTe detector architecture for simultaneous 3-band IR detection was developed.

Challenges. The major challenges for the sensor are in (1) developing the molecular beam epitaxy technology to grow two to three layers of HgCdTe of different composition monolithically, (2) fusing the data obtained therefrom into a synergistically superior video image, (3) placing the active receiver on the FPA that will require the development of advanced readout circuits with increased complexity and charge handling capacity, and (4) condensing the smart readout circuitry into a 25-µm cell size for ground applications and a 60-µm cell-size, radiation-hardened cryogenic complementary metal oxide semiconductor for space. Space system challenges include developing technologies to discriminate distant, cold targets (warheads and satellites) against a cold background (space).

Milestones/Metrics.

FY2000: Demonstrate feasibility of multispectral detector arrays grown directly on silicon.

FY2001: Demonstrate large-area (480 x 640 and 1,000 x 1,000) dual-color (MWIR/LWIR) FPA with optical interconnects and eye-safe LADAR.

FY2002: Demonstrate large-format (1,000 x 1,000) space LWIR QWIP FPA. Demonstrate laser rangefinding and target profiling on two-color FPA.

FY2003: Demonstrate integrated, multicolor, large-area (1,000 x 2,000) FPAs with parallel optical readouts, active LADAR, and 120 K operating temperature.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. C. THORTON USA/DBBL	Maj Steve CLIATT, USAF SAF/AQRT	Dr. Susan TURNBACH ODUSD(S&T)/SS
	Dr. Stuart HORN USA/NVESD	
	Dr. B. SINGARAJU AFRL	

SE.65 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602120A	H16	0.0	0.5	0.5	0.5	0.0	0.0
0602601F	4846	0.0	2.4	2.4	0.0	0.0	0.0
0602601F	8809	1.7	0.0	0.0	0.0	0.0	0.0
0602705A	H94	2.6	3.2	3.4	3.6	0.0	0.0
0602709A	H95	0.9	1.5	4.9	5.2	0.0	0.0
0603401F	2181	0.0	1.9	2.1	0.0	0.0	0.0
0603401F	3784	1.4	0.0	0.0	0.0	0.0	0.0
	DTO Total	**6.6**	**9.5**	**13.3**	**9.3**	**0.0**	**0.0**

SE.66 Packaging and Interconnect for Multiple Technologies

Objectives. Develop techniques for the fabrication, protection, assembly, and integration of digital, analog, microwave, and millimeter-wave signals into a single format. Mission-capable commercial electronic devices and packaging techniques will be developed for military applications. To realize the performance improvements at the system level, advanced packaging approaches such as mixed-signal multichip modules, chip-scale packaging, extremely high-bandwidth packages, chip-on-board, and 3D interconnect techniques must be employed. Die optimization approaches that can provide 10X lower power and 4X speed enhancement must also be explored.

Payoffs. Significant military capabilities such as smart weapons, secure wireless communications, covert tags, and tactical information assistants will be enabled by more integrated advanced packaging and interconnect approaches. This will allow more functionality per unit area, higher reliability, and lower subsystem costs. As an example, integration of bare-die analog data accumulator circuits into a single, quad flat-pack footprint for airborne applications provides the same functionality in one-fifth the area. An accomplishment of this DTO has been the demonstration of the ChipSeal process for avionics systems with a 2X–5X increase in life. In FY99, buried passive components showing 50% reduction in passive component area for the Discriminating Interceptor Technology program were demonstrated.

Challenges. Packaging technologies must (1) reliably survive adverse military ground, sea, air, and space operating and storage environments; (2) leverage commercial packaging manufacturing capabilities; (3) meet low-weight and small-volume requirements of compact sensors; and (4) be affordable in low-to-moderate production quantities. Specific technical challenges that must be overcome include hermeticity, EM interference and isolation, thermal management, high-density interconnects, low-loss/high-Q circuits, and multitechnology design and simulation.

Milestones/Metrics.

FY2000: Demonstrate a high-precision (2% impedance control, less than 5-mV noise suppression, 100-dB analog-digital isolation) MCM technology for packaging circuits.

FY2002: Demonstrate die-optimized interconnects integrated into 3D assemblies.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Viktor JONKOFF JSF	Maj Steve CLIATT, USAF SAF/AQRT	Dr. Susan TURNBACH ODUSD(S&T)/SS
Capt Wesley KREMER, USAF ACC/DRA	Mr. Al TEWKSBURY AFRL	

SE.66 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2002	0.9	0.9	1.3	0.0	0.0	0.0
0602601F	4846	0.0	0.3	0.3	0.0	0.0	0.0
0602601F	8809	0.3	0.0	0.0	0.0	0.0	0.0
0603203F	69CK	0.4	0.0	0.0	0.0	0.0	0.0
0603401F	2181	1.1	1.0	1.1	0.0	0.0	0.0
	DTO Total	**2.7**	**2.2**	**2.7**	**0.0**	**0.0**	**0.0**

SE.67 Hyperspectral Applications Technology

Objectives. Develop and demonstrate hyperspectral (HS) imaging technology from air and space platforms for two promising domains of defense applications: first, for battlespace environment characterization of both the terrestrial and the littoral ocean environments; and, second, for tactical target detection, characterization, and identification.

Payoffs. This DTO will demonstrate near-real-time detection of tactical targets with a high probability of detection (P_d) and a low false-alarm rate (FAR) whether targets are camouflaged, partially concealed, or exposed. It will demonstrate optical characterization of broad swaths of littoral ocean to identify features including water depth and clarity, and provide data for developing and validating coastal oceanographic models. It includes characterizing the terrestrial battlespace—classifying soil and vegetation types, analyzing trafficability, and identifying features and lines of communication. This DTO provides the technology to characterize the battlespace and isolate targets from clutter and camouflage. Collaboration in joint data collection, cooperative analysis, and shared exploitation among HS technology efforts under this DTO and with the Central Measurement and Signal Intelligence Office maximizes synergy.

Challenges. The principal challenges are developing, demonstrating, and validating the processing algorithm technologies tailored for specific applications' domains that can provide the high P_d, low FAR required for tactical targeting, and the high accuracy in terrain or littoral ocean feature identification required for battlespace environment characterization. Another major challenge is managing the large volume of data produced by HS imagery (up to 40 Gbytes per image) by pursuing innovative smart sensor and data exploitation technologies. Extending HS sensing into the night from the current daytime-only, reflected-sunlight technology (visible to near-IR) requires development of both medium- and long-wavelength infrared (MWIR/LWIR) HS sensors and new processing algorithms.

Milestones/Metrics.

FY2000: Demonstrate MWIR and LWIR hyperspectral data exploitation algorithms and baseline visual-to-SWIR terrain categorization algorithms and thermal ATR algorithms. Complete initial design of appropriate spectral/spatial algorithms. Demonstrate characterization of ocean environment from space with large area image of coastal zone (30 km x 200 km) with a moderate ground sample distance (GSD) (30 m) to identify coastal oceanographic features. Demonstrate near-real-time onboard processing with direct downlink of ORASIS compressed data to ship tactical terminals, and near-real-time day–night detection/cueing for full range of tactical targets from a UAV with a 1-m to 2-m GSD HS sensor cueing a high-resolution visible sensor.

FY2001: Complete implementation of spectral/spatial algorithms for VIS-to-SWIR and LWIR processing. Both detection and identification algorithms implemented. Demonstrate VIS/NIR/SWIR HS sensing from space at 8-m GSD over a 5- x 20-km image area with data downlink for follow-on ground processing for day detection of larger tactical targets. Validate space-based subpixel target detection algorithms and terrain classification algorithms. Validate ocean products for a range of coastal environments. Develop a 1-year time series of hyperspectral data for 50 representative coastal ocean sites and 8 target-rich terrestrial sites.

FY2002: Continue to develop a time series of hyperspectral data products for 50 coastal sites to document inter-annual variability. Complete algorithm refinement. Interim software available. Improve false target discrimination 2X over current single-band approaches for targets in the clear with light to moderate clutter. Improve terrain classification performance for four classes with a 2X reduction in misclassifications.

FY2003: Complete design and implementation of spectral/spatial algorithms for other secondary input sources such as digital terrain elevation data, radar, and fluorescence. Implement appropriate compatibility constraints. Demonstrate data fusion techniques and advanced algorithms for joint air/space target detection and identification; MARS flight test and demonstration. Continue to build the time series of hyperspectral data for 50 coastal ocean sites and hyperspectral data to validate the next generation of coastal oceanographic models.

FY2004: Complete integration of algorithms exhibiting combined terrain categorization and targeting capabilities to improve false target discrimination 5X over current single-band approaches in light clutter, improve target detection performance by 20% for highly obscured (50% visible) targets, and improve terrain classification performance for 10 classes with a 2X reduction in misclassifications.

Customer POC

Dr. Bill JEFFREY
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Mr. Dave THACKER
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Maj Steve CLIATT, USAF
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Mr. Dave FIELDS
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Ms. Connie GRAY
USA/TEC

Dr. John SCHUMMERS, USAF
AFRL/VSBC

USD(A&T) POC

CAPT Dave MARTIN, USN
ODUSD(S&T)/IS

COL John E. O'PRAY, USA
ODDR&E/SA

Mr. Tom WILSON
ODUSD/SP

SE.67 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602120A	H16	0.3	0.3	0.3	0.3	0.4	0.0
0602232N	00000	3.2	0.0	0.0	0.0	0.0	0.0
0602234N	00000	2.0	0.0	0.0	0.0	0.0	0.0
0602705A	H94	0.2	0.2	0.2	0.2	0.2	0.0
0602784A	855	0.7	0.7	0.7	0.7	0.7	0.0
0603401F	3834	11.3	3.7	3.6	0.0	0.0	0.0
0603762E	SGT–02	12.9	0.0	0.0	0.0	0.0	0.0
	DTO Total	**30.6**	**4.9**	**4.9**	**1.3**	**1.3**	**0.0**

SE.69 Autonomous Distributed Sensors

Objectives. Demonstrate a capability to detect, track, classify, and report battlefield and undersea threats with distributed, unmanned sensors using a multiplicity of acoustic and magnetic emissions from the threat. Battlefield threats include tanks and other heavy vehicles such as transportable erector launchers, helicopters, and aircraft. Undersea battlespace threats to be detected are submarines, surface ships, and mine deployment activities. The use of these low-cost, battery-powered, networked sensor fields extends the situational awareness of the warfighter over a greatly increased area compared to that possible with manned systems and vehicles. These will be primarily passive receivers of emitted energy and, as such, are relatively clandestine and applicable to prehostilities battlespace preparation. (Note: This DTO complements work in A.24, Unattended Ground Sensor ACTD (completed FY99), which is focused on continuous surveillance of choke points to permit target identification and cueing and improved reporting of localized weather conditions.)

Payoffs. Autonomous distributed sensors provide the joint force commander with surveillance options in areas where current and projected capability is either too costly, too overt, too slow to deploy, or limited by the number of manned platforms available. This added capability will give daily updates of all threats operating in the surveillance field (precluding operational surprise) and give tactical options to the joint forces commander to either attack or evade. In FY98, the project demonstrated a commercial technology underwater acoustic communications 12-node network with 10-km node spacing and 100-bps data rate.

Challenges. Technical barriers include autonomous processing for detection and classification; node designs for rapid deployment, long-life, real-time operation, and low cost; sensor-to-gateway communications networks; communications gateways to the global network; and counting and classification by type of clustered vehicles on the battlefield.

Milestones/Metrics.

FY2000: Resolution of closely spaced multiple targets on the battlefield.

FY2001: Initial test of A-Cubed Drifting Line Array.

FY2002: Demonstrate deployable, distributed array with real-time magnetic classification.

FY2003: Demonstrate active and passive in-buoy signal processing algorithms at sea. Initial field test of Smart LADAR sensor system. Real-time, in-node automatic acoustic detection and classification of submarines.

FY2004: Show military utility of autonomous node in a fleet battle experiment or SHAREM.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Capt. J. NIFONTOFF SPAWAR, PD18	Dr. Frank HERR ONR	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.69 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602314N	00000	7.8	6.0	4.5	4.3	3.8	0.0
0603747N	R2142	3.5	5.3	7.3	8.8	6.4	0.0
	DTO Total	**11.3**	**11.3**	**11.8**	**13.1**	**10.2**	**0.0**

SE.70 Integrated Compact Electronic Sensors for Smart SensorWebs

Objectives. Develop the electronic component and integration technologies for the next generation of lightweight, compact sensors for Smart SensorWebs and other applications requiring small and internetted sensors for military space, air, and ground applications. The focus of this DTO is on two key technology areas: (1) the miniaturization and integration of sensor devices and components, and (2) the networking and data fusion of multidomain sensors arrays. Device technologies include on-chip/off-chip integration of RF, IR, acoustic, seismic, magnetic, and microelectromechanical sensors (MEMSs), low-power RF, and digital electronics. These technologies will enable the demonstration of extremely efficient, rugged, low-power, fused and internetted sensor technologies capable of reliable, remote, unattended operation in the required military environment.

Payoffs. The developed technology will enable distributed sensor systems that are "capability-centric" to meet multiple military requirements such as multidomain situation awareness of the battlespace, health status of the individual warfighters, autonomous targeting and navigation for precision munitions and robotic vehicles, and conditioned-based maintenance of complex military platforms. These integrated and networked sensors will provide fine-resolution details of targets and scenes from air, ground, and space platforms to provide precision targeting and autonomous navigation. In FY99, the design of low-power-dissipation X-band amplifiers and analog-to-digital converters (ADCs) for compact sensor applications was initiated.

Challenges. Packaging and integration of multiple technologies is critical to achieving the ultra-small, lightweight requirements (5X–10X packaging density improvements), including multiple technologies on chip, packageless chips, and 3D integration, including multiple technology CAD tools. Low-power semiconductor technologies will be required for the reduction of high-performance ADC and DAC power consumption by a factor of 100 to 1000. High-efficiency RF generation and reception will require innovative concept developments such as monolithic class-E or switch-mode power designs for ultra efficiency above 70%, and micropower-cued receiver designs. Innovative internetting and sensor data fusion algorithms are critical to establishing the low-power, low-bandwidth digital communications for the warfighter among widely distributed, multidomain smart electronic sensors.

Milestones/Metrics.

FY2000: Develop local network communications protocols and demonstrate visible imaging microsensors and IR imaging microsensor design. Demonstrate X-band LNA for spaceborne systems having less than 20-mW dissipation and noise figure under 1.5 dB. Demonstrate capability to predictively simulate complex microfabricated mechanical structure. Demonstrate capability to scale-up advanced transducer to 10 x 10 array.

FY2001: Demonstrate small-scale integrated network of acoustic, seismic, and imaging microsensors. Demonstrate ultra-high-efficiency X-band power amplifier having radiation hardness, 70% efficiency, and 20% bandwidth.

FY2002: Demonstrate micro-inertial navigation systems for the individual soldier or robotics platforms; and integrated network of acoustic, seismic, and IR imaging microsensors with unattended operation for 120 days. Demonstrate subassembly-level coating processes for multitechnology, multichip modules.

FY2003: Complete fabrication of network of integrated microsensors with package sizes less than 1 in^3 for selected demonstration application. Demonstrate programmable low-power ADCs (goal is less than 1 microwatt per gate) suitable for space applications.

FY2004: Perform final demonstrations of highly integrated (preferably packageless) combinations of sensor devices, MEMs, and digital processing elements for the selected applications. Show the ability to survive 130°C and 85% relative humidity with less than a 5% failure rate.

Customer POC

Maj Tracy KABER, USAF
SMC/XR

Mr. Chris KEARNS
USAIC

Capt Wesley KREMER, USAF
ACC/DRA

Service/Agency POC

Mr. Tim KEMERLEY
AFRL/SND

Dr. John MILLER
ARL/SEDD

USD(A&T) POC

Dr. Susan TURNBACH
ODUSD(S&T)/SS

SE.70 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602120A	H16	1.2	1.1	1.4	1.4	0.0	0.0
0602204F	2002	3.1	4.2	5.4	3.6	2.7	0.0
0602204F	6096	0.6	0.0	0.0	0.0	0.0	0.0
0602705A	H94	0.3	0.3	0.3	0.3	0.0	0.0
0602709A	H95	1.4	1.5	4.1	3.8	0.0	0.0
0602712E	MPT–02	2.6	6.0	5.0	0.0	0.0	0.0
0603739E	MT–04	7.8	0.0	0.0	0.0	0.0	0.0
	DTO Total	**16.9**	**13.0**	**16.1**	**9.0**	**2.7**	**0.0**

SE.71 Advanced Multifunction RF System Components

Objectives. Develop the electronic component technologies to realize advanced multifunction RF systems, such as surveillance, illumination, weapon control, electronic warfare, radar, communications, and identification friend or foe for operation over the 1-GHz to 44-GHz frequency range. The investment is focused in four military-essential component areas of development: wide-bandwidth, high-efficiency power amplifiers; direct digital synthesis (DDS) components; high-speed analog-to-digital converters (ADCs); and photonic and digital beamforming. The DTO develops enabling critical components that will form the foundation for future DoD multifunction RF systems. The scope of work covers the design, fabrication, test, and packaging of the essential components. The subject DTO leverages off of other existing DTOs, including SE.57, Analog-to-Digital Converter, SE.36, Photonics for Control and Processing of RF Signals, and SE.39, Wide-Bandgap Electronic Materials Technology.

Payoffs. This DTO will result in anticipated life-cycle cost savings of hundreds of millions of dollars per ship for 21st century surface combatant ships accruing from significantly reduced parts count, logistics, operations, maintenance, and upgrades. In addition, multifunction arrays greatly enhance stealth characteristics. Similar benefits are anticipated for airborne and space-based platforms in addition to providing the 30% to 75% size and weight reductions required for sensor systems on future aerospace vehicles. Developing affordable multifunction K-band arrays will provide increased lethality, accuracy, and all-weather operations.

Challenges. The technical challenges encompass direct digital synthesis of signals over multioctave bandwidths up through 40 GHz; integral modulation and instantaneous bandwidth as high as 2 GHz; logic circuits running at millimeter-wave clock speeds; and low loss distribution and beamforming approaches. Broadband high-efficiency power amplifiers and low-power dissipation, high-dynamic-range receivers are other challenges. Operation over adverse military environments presents a major challenge.

Milestones/Metrics.

FY2000: Develop and demonstrate high-speed logic circuits that support wide-bandwidth DDS and high-speed ADC components. Develop packaging and interconnect approaches for wide-bandwidth, X-band space-based active aperture power amplifiers. Trade-off photonic/digital approaches for wideband beamformers.

FY2001: Demonstrate a DDS using low-parasitic HBT technology whose output signal can be set to any frequency between 1 GHz and 5 GHz and capable of 500-MHz modulation. Demonstrate a 10-bit, 3-GHz sampling InP HBT-based ADC. Demonstrate multibeam performance with a Ka-band Rotman lens.

FY2002: Demonstrate reconfigurable RF beamformers operating over the 1-GHz to 44-GHz range. Demonstrate a power amplifier operating over the 4-GHz to 20-GHz band with 50% power added efficiency. Demonstrate integrated transmit/receive functions for wide-bandwidth, X-band space-based active apertures.

FY2003: Demonstrate dynamically programmable ADCs capable of greater than 16 bits of resolution at 10-MHz bandwidth, 11 bits of resolution at 500-MHz bandwidth, and 8 bits of resolution at 4 GHz. Develop 4-GHz to 20-GHz DDS components.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Maj Tracy KABER, USAF SMC/XR	Mr. Tim KEMERLEY AFRL/SND	Dr. Susan TURNBACH ODUSD(S&T)/SS
Capt Wesley KREMER, USAF ACC/DRA	Mr. Max YODER ONR	
Mr. Tom READY DD–21		

SE.71 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2000	0.4	0.0	0.0	0.0	0.0	0.0
0602204F	2002	0.9	3.8	4.9	7.2	0.0	0.0
0602204F	6096	0.7	0.0	0.0	0.0	0.0	0.0
0602204F	7622	0.0	0.7	0.0	0.0	0.0	0.0
0602234N	00000	7.0	7.0	7.0	7.0	0.0	0.0
0602705A	H94	0.5	0.4	0.0	0.0	0.0	0.0
	DTO Total	**9.5**	**11.9**	**11.9**	**14.2**	**0.0**	**0.0**

SE.72 Advanced Multifunction RF System

Objectives. Demonstrate a simultaneous multibeam, multifunction (radar, electronic warfare, and communication) RF system. This will be accomplished by integrating these functions in a common, broad RF band into a common pair of apertures, and developing the necessary dynamic allocation of the aperture array elements, the associated signal generation, and processing assets. This will be accomplished in an open architecture configuration to permit cost-effective technology and functional upgrades.

Payoffs. The Advanced Multifunction Radio Frequency System (AMRFS) provides major life-cycle cost reduction due to the reduction in the number of separate RF hardware systems, increased commonality of equipment, reduction in logistics tail, and reduction in personnel required to maintain and man such an integrated system. Also the reduction in the number of antennas leads to a reduction in the radar cross section and, thus, improved survivability. In addition to the technology advances anticipated by this program, substantial combat effectiveness improvements accrue to the platform and the warfighter through the flexibility of the allocation of the platform's RF power to the highest priority need. The reduction in the numbers of antennas enhances shipboard topside design with improved antenna siting. An integrated systems management approach of the associated radar, electronic warfare, and communications functions and of the operating EM spectrum further enhances combat effectiveness. In effect, the system is in the software thereby enabling any platform to accommodate legacy systems while permitting cost-effective upgrades to enhance the capability of the warfighter.

Challenges. A broadband RF system (5:1 bandwidth) requires efficient, broadband radiating elements; linear, broadband, high-power amplifiers; and high-performance analog-to-digital and digital-to-analog converters. Isolation is a major concern, even with separate apertures. Challenges also include the development of a resource manager to control the beamforming and analysis for both the transmit aperture and the receive aperture, and the integration of the inputs from the receive aperture and other sources in determining the appropriate transmit functions. This dynamic allocation of the array elements, which enables timely array aperture access by the combat functions, will require a resource allocation manager of unusual flexibility. Finally, there are certain requirements (e.g., polarization) that are demanding on arrays when the beams are off boresight.

Milestones/Metrics.

FY2000: System design to provide a 5:1 (initially 1-GHz to 5-GHz) system with a threefold reduction in function-specific antennas. System controller architecture to accommodate combat functions on a real-time demand basis; realization of interbeam and interfunction signal isolation requirements (currently estimated at greater than 100 dB); signal and data processing based on COTS components.

FY2001: Demonstrate individual transmit and receive apertures and resource allocation manager with the ability to dynamically reallocate subapertures, a multibeam transmit aperture subsystem, and a multibeam receive aperture system.

FY2003: Demonstrate integrated system over 1-GHz to 5-GHz with dynamically reallocatable subapertures with at least one beam per transmit subaperture and three beams per receive subaperture with an instantaneous bandwidth of 500 MHz. Full polarization flexibility to 50 deg off boresite will be demonstrated at 95% purity.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT T. Lad WEBB, USN CVX	Dr. B. R. JUNKER ONR 31	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.72 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603238N	R2145	5.4	4.6	0.0	0.0	0.0	0.0
0603794N	X2091	15.9	13.6	10.0	10.0	0.0	0.0
	DTO Total	**21.3**	**18.2**	**10.0**	**10.0**	**0.0**	**0.0**

SE.73 E-Scanned Antenna for Airborne Surveillance, Warning, and Control ATD

Objectives. Develop electronically scanned surveillance antennas (ESAs) with embedded 360-deg identification friend or foe (IFF) for airborne surveillance platforms. Current antenna configurations are rotodome-based and are mechanically scanned in azimuth with fixed elevation coverage. These antennas typically require 10 seconds to cover 360 deg and in some configurations the IFF antenna alignment is 180 deg of the boresight of the surveillance antenna. This DTO matures advanced IFF technologies and enabling technology efforts.

Payoffs. This DTO provides a rotodome-configured (form, fit, and function with existing aircraft) antenna that is fully scanned electronically in azimuth and providing high-rate volume surveillance with rapid revisit scanning for track-while-scan operations. The E-scanned antenna will also provide 20% weight savings through elimination of mechanical drive train and rotary coupler hardware and increase affordability by a factor of 2. Coordination with the Air Force for potential application to the AWACS will provide technology implementation for future surveillance systems. In FY99, fabrication of an E-scanned antenna at UHF was completed for demonstration of antenna performance and testing at the Pacific Missile Range facility in Kauai, HI.

Challenges. The technical challenges are to develop a vertically polarized antenna with an operating frequency range of 400 MHz to 450 MHz and scalable to 3 GHz with embedded L-band IFF antenna configuration that is compatible with existing rotodome housings. Achieving antenna gain of 21 dB with scan update rates of 100 ms or less and increasing mean time between failures by a factor of 3 are major technical challenges.

Milestones/Metrics.

FY2000: Transition to advanced technology demonstration under PE 0603792N and initiate fabrication of a flyable airborne antenna system.

FY2001: Complete fabrication of ATD antenna characterization and initiate E2C aircraft integration studies.

FY2002: Complete ATD at mountain-top radar test facility in HI and prepare transition plan and transition to PEO–T, PMA–231 Radar Modernization program under PE 0204152N.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Walter BAHR NAVAIR, PMA–231	Ms. Mun Won FENTON ONR 31	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.73 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602232N	00000	1.1	0.9	0.9	0.0	0.0	0.0
0603792N	R1889	5.5	4.3	4.5	0.0	0.0	0.0
	DTO Total	**6.6**	**5.2**	**5.4**	**0.0**	**0.0**	**0.0**

SE.75 Precision Surveillance and Targeting Radar

Objectives. Develop and demonstrate new radar technologies and techniques for detection, location, imaging, and exploitation of both stationary and moving tactical targets in the littoral environment using ultra-high-resolution synthetic aperture radar (SAR) with clutter cancellation, inverse synthetic aperture radar (ISAR), moving target indicator (MTI), and moving target imaging (MTIm); and provide targeting-quality geolocation coordinates through use of an integrated Global Positioning System /Inertial Navigation System (GPS/INS). Based on the success of multimode airborne radar technology, this effort provides the next critical demonstration (airborne) in the development process.

Payoffs. Precision air-to-surface surveillance and strike capabilities are critical to warfare in the littoral environment. The precision surveillance and targeting (PS&T) radar employs simultaneous synthetic aperture and MTI techniques with high-resolution MTIm, which provides the warfighter with superior situation awareness including the ability to simultaneously detect, identify, and target stationary and moving threats. Integrating the SAR, ISAR, MTI, and MTIm with a GPS/INS capability provides "all-speed" target detection, identification, and location.

Challenges. MTIm is a new technology and has not been demonstrated in flight. To provide this capability, a scalable tile array antenna is needed to provide detection, imaging, and location of slow-speed (in-clutter) ground targets at tactically significant ranges (greater than 150 nmi). Development of scalable tile array antenna technology enables unique clutter-cancellation and micro-doppler discrimination for target identification and enables significant improvements in minimum discernable velocities typical of slow-moving (less than 3 kt) ground targets and small craft at sea.

Milestones/Metrics.

FY2000: Using AN/APY–6 configuration, install MMR into a Fleet EP–3 or S–3 to further characterize system modes and to yield performance specifications for the scalable tile array antenna. Conduct extensive air-to-ground flight test that demonstrates detection, location, and identification of target(s) moving at 4 km/hr to 80 km/hr over land and sea.

FY2001: Initiate design and laboratory test of a 1-ft X 12-ft tile array antenna.

FY2002: Initiate development, fabrication, and integration of a tile array antenna into E2C aircraft in preparation for flight demonstration.

FY2003: Conduct flight demonstrations to validate moving target detection and identification in typical operating speed regimes at greater than 150 nmi in varying land and sea clutter.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
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SE.75 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602232N	00000	2.3	2.3	2.4	2.1	0.0	0.0
	DTO Total	**2.3**	**2.3**	**2.4**	**2.1**	**0.0**	**0.0**

SE.77 Infrared Decoy Technology

Objectives. Develop and demonstrate infrared IR decoy technology for enhanced self-protection of aircraft and surface ships. The program will develop materials and dispensing technologies for both air and sea applications, and demonstrate such technologies against captive IR seekers.

Payoffs. Successful achievement of this DTO will enhance the survivability of airborne and seaborne combatants against advanced IR missiles with decoy rejection techniques and algorithms. With regard to aircraft self-protection, the DTO will demonstrate the ability of advanced IR decoy countermeasures to significantly improve aircraft self-protection against the advanced strategic and tactical expendable (ASTE) Tier II threats. These devices and technologies can then be applied in advanced flare-dispensing techniques using multiple expendables to enhance the current ASTEs designed to counter Tier I threats. Regarding ship IR self-protection, the DTO will demonstrate decoy technology that is compatible with the currently deployed MK–36 Decoy Launch System (DLS) and that provides increased seduction capability over currently fielded point-source decoys.

Challenges. The key overall technical challenge is to improve the spatial/geometric behavior of countermeasures without sacrificing in-band intensity requirements or spectral balance between IR bands (e.g., mid-wave versus short-wave). The issue of spatial geometry is critical with regard to the need for replicating the spatial extent of a ship (versus easily discriminated IR point source decoys), and remains paramount in view of future imaging IR threats to all warfighter platforms. (Hence, IR decoy efforts beyond FY00 will be integrated into the demonstrations under DTO SE.79 (formerly WE.47), Imaging IR Seeker CM Technology.) In the case of aircraft self-protection, the challenge is twofold: optimizing the spectral balance of conventional materials, and improving the aerodynamic performance of special IR materials. This latter class of materials exhibits good spectral balance, but suffers from an inherently low ballistic coefficient (i.e., high drag), which causes rapid separation from the dispensing aircraft. For the ship decoy, the technical challenge is to dispense the IR payload in a timed sequence that is both tactically easy to implement and operationally compatible with the MK–36.

Milestones/Metrics.

FY2000: Demonstrate MK–36 DLS-compatible ship decoy technology with 20X improvement in IR spatial extent while retaining sufficient mid-wave and long-wave IR intensity to decoy current antiship missile threats.

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SE.77 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2000	0.4	0.0	0.0	0.0	0.0	0.0
0602270N	00000	1.0	0.0	0.0	0.0	0.0	0.0
	DTO Total	**1.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

SE.78 Coherent RF Countermeasures Technology

Objectives. Provide a power-efficient, coherent radio frequency countermeasures (RFCM) capability to protect friendly airborne and surface platforms from high-power threat weapon systems that use advanced radar processing techniques. This tri-service effort will attack this objective on two technology fronts: digital RF memory (DRFM) architectures, and phased-array microwave power module (MPM) transmitters/jammers.

Payoffs. The pursuit of multichannel, modular chip-set DRFM designs as a core signal exciter at the electronic warfare (EW) receiver-transmitter (transceiver) interface will yield the ability to rapidly demodulate, accurately store, and precisely replicate or alter enemy radar waveforms for retransmission by a jammer, thus degrading or denying the hostile threat sensors' ability to acquire and track targets. Advancements in DRFMs will also speed the transition of digital EW receiver architectures being pursued by the services. Transmitters employing MPMs and millimeter-wave power modules (MMPMs) have the potential of a tenfold volume reduction and a greater than twofold increase in prime power efficiency compared to typical microwave/millimeter wave traveling wave tube (TWT) or GaAs solid-state-based transmitters. Advancements in EW MPM technology will also be applied to the constrained form factors of towed decoys. Solid-state monolithic microwave integrated circuit (MMIC) amplifiers will increase prime power efficiency, power output, and bandwidth, lending themselves to array applications. The emerging technologies being advanced under this DTO will provide new coherent countermeasures and high-efficiency, high-power, multibeam, polarization-agile transmitter capabilities for support, stand-in, and escort jamming missions as well as self-protection countermeasures, thus enhancing the tri-service survivability of surface platforms and penetrating airborne platforms.

Challenges. Traditional, noncoherent ECM techniques, such as noise jamming, are largely ineffective against modern coherent threats. Such radar systems use sophisticated monopulse, pulse Doppler, or processing gain or filtering techniques to deny effective and deceptive masking of friendly forces platforms. ECM signal coherency and power and spectral energy efficiency of jamming signals are absolutely critical to successful penetration of such radar processing. In an upgrade/retrofit/P^3I environment, given the sheer number of operational EW systems involved, cost is also a challenge. Development goals of a low-cost ($5,000 (FY98 $)) miniaturized coherent exciter and ECM techniques generator and low-cost ($10,000 (FY98 $)) jammer power modules are key elements of the tri-service goals. Very high bandwidth DRFMs will also require high-speed, multibit analog-to-digital and digital-to-analog converters.

Milestones/Metrics.

FY2000: Integrate transceiver, monolithic DRFM, and technique controller to demonstrate a coherent exciter. Fabricate 16 wideband MMIC modules and design MMIC array antennas. Conduct R&D on high-power MMPMs for MMW countermeasures systems. In Phase I, a prototype MMW power booster will be integrated with a solid-state driver. Develop wide-bandwidth Phase I DRFM and initiate technique development.

FY2001: Complete tri-service coherent CM architecture; fabricate and demonstrate ultra-wide-bandwidth ECM MPM transmitter; demonstrate 8 x 8 polarization diverse MMIC jammer array; initiate coherent electronic attack jamming pod technology demonstrator (integration of transceiver, DRFM exciter, MPM arrays, and controller technology subelements). Integrate 4X wideband DRFM into testbed and conduct field testing. In Phase II, a second MMW booster will be prototyped, redesigned, and packaged.

FY2002: Demonstrate counter surveillance radar capability DRFM in testbed. Begin multiplatform/multifunction ECM investigations. In Phase III, the primary emphasis will be to design and prototype a MMW micro-TWT. A power output of 40 W and a gain of 50 dB is required. The MMW micro-TWT size will be 6 x 6 x 1.8 in. A critical design review will be conducted and a MMW micro-TWT will be delivered. Increase instantaneous bandwidth (Phase II) and test wide-bandwidth DRFM.

FY2003: Integrate coherent jamming architecture into pod or UAV configuration, and conduct ground test. Test wide-bandwidth (Phase II) DRFM against an NCTR radar.

FY2004: Conduct laboratory demonstrations of multiplatform/multifunction hardware.

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SE.78 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2000	0.2	0.0	0.0	0.0	0.0	0.0
0602204F	7622	0.0	0.2	0.2	0.2	0.2	0.0
0602270A	442	2.3	3.5	3.7	2.7	2.7	0.0
0602270N	00000	1.6	1.7	1.7	1.8	0.0	0.0
0603270F	431G	1.0	0.6	0.0	0.0	0.0	0.0
0603270N	R2090	0.7	0.7	0.7	0.8	0.0	0.0
	DTO Total	**5.8**	**6.7**	**6.3**	**5.5**	**2.9**	**0.0**

SE.79 Imaging Infrared Seeker Countermeasures Technology

Objectives. Develop requirements for infrared countermeasure (IRCM) technology necessary to defeat next-generation staring and scanning focal plane array (FPA) imaging infrared (I^2R) seekers. Specific advanced threat technologies will be assessed and quantifiable requirements developed for advanced expendables, lasers, and signature control techniques. The overall goal is to improve effectiveness of countermeasures by 40X–50X over present-day warfighter capabilities for air, land, and sea platform self-protection from imagers.

Payoffs. It is envisioned that advanced, spatially extended decoys (possibly directionally dispensed), higher-brightness laser jammers, and advanced signature control technology, used alone or synergistically, will be needed to defeat the I^2R threat. Consequently, a major payoff will be the definition of new performance requirements from the parallel technology development efforts currently underway. Success of the tri-service effort will necessarily and significantly boost the survivability of both air- and surface-based combatants against the imaging I^2R. The techniques developed will be of generic usefulness and will have wide application to a large percentage of the U.S. weapon platforms.

Challenges. Defeating the I^2R threat may require area decoys encompassing 10X more area than existing or near-term developmental decoys. In addition, these advanced decoys may need to be directionally deployed to obscure the target. Laser jammers with 20X–100X the brightness may be needed to defeat the I^2R threat. This would require 2X–3X more powerful lasers with one-half to one-third the divergence used in conjunction with more precise pointing and tracking systems. Advanced signature control technology may also be needed to disrupt the I^2R tracker aimpoint. All techniques must be brought to bear in a cooperative fashion to defeat imagers.

Milestones/Metrics.

FY2000: Identify and obtain foreign FPAs.

FY2001: Report on IRCM vulnerability of foreign and domestic FPAs. Report on susceptibility of antiair track algorithms. Specify IR decoy characteristics.

FY2002: Develop antiair surrogate seeker hardware.

FY2003: Develop and test IRCM concepts on imaging seeker hardware (surrogate/real). Field test candidate IR decoy technologies.

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SE.79 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602204F	2000	0.2	0.0	0.0	0.0	0.0	0.0
0602204F	7622	0.0	0.2	0.2	0.2	0.0	0.0
0602270A	442	2.9	3.0	2.9	3.1	0.0	0.0
0602270N	00000	0.4	0.5	0.5	0.5	0.0	0.0
0603270F	691X	0.2	0.1	0.0	0.0	0.0	0.0
0603270N	E2194	0.0	0.0	0.7	0.9	0.0	0.0
	DTO Total	**3.7**	**3.8**	**4.3**	**4.7**	**0.0**	**0.0**

SE.80 Missile Warning Sensor Technology

Objectives. Demonstrate advanced multispectral sensor and algorithm technology for long-range detection of IR guided missile threats and situation awareness (SA) capability for air, sea, and ground platforms. The SA capability will combine missile warning, defensive IR search and track (IRST), and forward-looking IR (FLIR) and navigation functions in a sensor/processor breadboard in order to achieve real-time demonstration of integrated algorithms. The advancements pursued are lower false-alarm rates, extended declaration ranges, affordable multispectral sensor technology, and real-time processed algorithms.

Payoffs. Current missile warning technology limits detection to the last few seconds of the engagement, resulting in marginal survivability for the warfighter. From this tri-service DTO, the warfighter will gain enhanced and more accurate missile warning, plus the additional benefit of improved survivability through better SA capability for air vehicles. The operational customer will thus be able to define requirements to tailor the passive IR system from a missile-warning-only capability to an SA capability. The dual-band missile warning focus will provide missile warning at long range for detection and handoff for laser IRCM/expendable countermeasures. The SA capability focuses on an affordable IR sensor/processor suite for tactical air, sea, and ground vehicles. The acquisition costs are being considered in advanced development to ensure an affordable threat warning and SA system. Success of this DTO will enable multiple transitions to new and retrofit platforms, including Joint Strike Fighter, Common Missile Warning P^3I, the ALQ–212, the Army's Horizontal- and Top-Attack Protection program, and the Navy's ship self-protection upgrades. The bottom line is greatly improved survivability for the joint warfighter with a totally passive intercept and SA capability.

Challenges. In comparison to current systems in the field, detection ranges must be extended and false alarms reduced (by 2X–10X) to provide unambiguous warning in time to initiate effective tactical maneuvers, deploy countermeasure decoys, or cue directed-energy jamming systems. The technical barriers include affordable multispectral focal plane arrays (FPAs) (both cryogenically cooled and uncooled detectors), multiaperture packaging, affordable processors, real-time processing algorithms, and clutter rejection techniques. The processors for running the algorithms from a six-sensor to a smaller ground vehicle missiles warning suite must be affordable to realize a low life-cycle cost. The multispectral FPA technology needed must have adequate sensitivity and simultaneous readout of multiple IR bands. Although attractive from a cost perspective, the uncooled sensor performance must be demonstrated in terms of detection range and false-alarm rate.

Milestones/Metrics.

FY2000: Demonstrate integrated sensor/processor for SA (missile warning, defensive IRST, FLIR/navigation) in a single aperture and 3:1 reduction in required apertures.

FY2001: Demonstrate real-time, uncooled, single-color warning system with 75% of the performance, 33% of the life-cycle cost, and 20% of the false-alarm rate of current systems.

FY2002: Demonstrate low-cost, two-color missile warning sensor against both ATGMs and SAMs.

FY2003: Demonstrate ability to detect top-attack munitions using low-cost, two-color missile warning system.

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SE.80 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602270A	442	1.9	2.0	2.0	1.9	0.0	0.0
0602270N	00000	0.2	0.0	0.0	0.0	0.0	0.0
0603270F	691X	0.5	0.0	0.0	0.0	0.0	0.0
	DTO Total	**2.6**	**2.0**	**2.0**	**1.9**	**0.0**	**0.0**

SE.81 Network-Centric Electronic Warfare Technology

Objectives. Develop 21st century (2010) advanced concepts/systems and risk-reduce enabling technologies to provide a coordinated, integrated, multiplatform (e.g., network-centric) EW capability. The vision of network-centric EW is to provide improved employment efficiency of individual EW assets, greater mission flexibility, and improved command and control of EW resources in order to enhance EW support to operational missions. The services' current EW operational concept is an evolutionary approach predicated on the first deployed equipment and technology dating back to the Vietnam War. By 2015, the DoD's only airborne tactical support jammer will end its service life. A number of key technologies common to a range of potential follow-on solutions have been identified in the fields of connectivity, networking of distributed architectures, EW payloads for airborne pods, and expendable UAVs, including the development of coherent-reactive exciters/jammers.

Payoffs. The risk-reduced technology will provide the next-generation (2010) network-centric EW capability, which will allow new warfighting capabilities. These capabilities have high effectiveness with substantial improvements over conventional approaches; generic responses with an ability to adapt to advanced threats and threat laydowns/scenarios; improved survivability through the use of low radar cross section combined with deceptive jamming and signature alteration techniques; open architecture to allow future flexibility and growth potential; reduced fratricide through coordinated and integrated operations of friendly sensors and jammers; the ability to employ a much wider variety of strike geometries (e.g., mainbeam and sidelobe); and a synergistic effect to augment lethal suppression of enemy defenses (SEAD).

Challenges. Traditional EW capabilities are effective against a large number of conventional threats, but they suffer due to poorly integrated reactive situational awareness with data fragmentation caused by poor real-time sensor fusion and correlation, misallocation of jammer resources, and fratricide among the available deployed assets. Effective EW against future fully layered integrated air defense systems that fuse sensor data from multispectral assets will require a network-centric EW system that utilizes both lethal and nonlethal SEAD. A system is coherent and reactive if it can detect and effectively jam a threat mode change with a minimum of effective radiated power before the threat detects the strike platform (e.g., within the threat's response time). The coherency and response time requirements for the next-generation EW systems are unique and are the most demanding technology drivers for the system.

Milestones/Metrics.

FY2000: Perform study to identify linking and network control requirements, command and control approach, and employment concepts.

FY2001: Develop top-level networked EW architecture/topologies. Conduct a link and nodal analysis and demonstrate the connectivity robustness.

FY2002: Demonstrate a small, low-cost specialized coherent EW receiver payload for airborne pods and small, expendable UAVs.

FY2003: Integrate and demonstrate a coherent jammer in an airborne pod or UAV (see SE.78). Integrate and demonstrate a reactive EW receiver.

FY2004: Demonstrate a distributed reactive network-centric EW concept using reconfigurable pods, precision geolocation, common datalinks, and unique UAV payloads. Demonstrate an ability to coordinate multiple jamming assets in an integrated manner.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
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SE.81 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602270N	00000	1.1	1.0	0.9	1.0	1.0	0.0
	DTO Total	**1.1**	**1.0**	**0.9**	**1.0**	**1.0**	**0.0**

SE.82 Battlespace Electronic Mapping

Objectives. Provide the platform commander with RF collection, detection, identification, and visualization capabilities. The goal is to take advantage of the inherent multifunction capabilities of modern C^3 systems to integrate RF collection and processing capabilities with advanced display and human-computer interface technology.

Payoffs. RF detection, identification, mapping, and visualization capabilities will provide the tactical commander with a real-time picture of the electronic order of battle (EOB) in his/her immediate area. The real-time picture of the EOB will provide tactical-level alerts, warnings, and threat locations. It will enable the execution of the Army's future intelligence system architecture. The technology being developed under this DTO will support real-time electronic mapping displays and EOB visualization capabilities with minimal analyst workload for relatively small operational Army, Navy, and Marine Expeditionary Force units. RF collection, processing, and display is required at lower echelons considering the trend of modern battlespace communications. Future threat communications systems will be using lower-power emitters with low probability of intercept/complex waveforms in a densely populated RF spectrum. Threats to C^2W systems will force increased standoff distances of U.S. support platforms. Thus, standoff collection platforms will not be able to provide complete coverage in this environment. Additionally, a networked information grid has the potential of distributing the battlespace electronic mapping and visualization to units without organic sensing/processing capabilities.

Challenges. The implementation of this DTO will require algorithm development, visualization tools, and a well-orchestrated operational implementation. Enhanced digital signal processing algorithms will need to be developed to process collected signals in real time and to identify, with sufficient fidelity, different emitters on the battlefield. Automated algorithms will need to be developed for data correlation and aggregation with similar information for higher echelons to determine targets of interest. Visualization and human–computer interface issues will need to be investigated to provide inexperienced or non-EW personnel with the ability to utilize and benefit from real-time EOB information. The implementation of the RF collection through planned communication equipment will require optimization of time-sharing and synchronization of multiple collectors. Implementation into current communications systems will require separate appliques. Models and simulations will be needed that utilize real-time EOB data to generate operational simulations that optimize unit assets, increase probability of correct emitter identification, and define data transfer to higher echelons.

Milestones/Metrics.

FY2000: Demonstrate interfaces to all requisite sensors and analysis sensors; DIS experiment to assess timing and operational concept; identify and test wideband antenna as multifunction collector; demonstrate 3D EOB data display and analysis tool for fleet electronic warfare simulation development; demonstrate simulation display for 2D/3D analysis and visualization (sensor and positional data) of T&E over networks (SIPRnet).

FY2001: Demonstrate ability to automatically recognize signals associated with top-10 value targets; automatically cue sensors based on selected high-value targets; manage and update mapping software with minimum of 15-min updates of all data. Demonstrate an applique to a current Army tactical radio for operation as a multifunction collector, and perform offline processing to produce a location accuracy less than 500 m. Demonstrate radar range equation with real-time EOB data.

FY2002: Demonstrate the ability to identify selected HVT to the serial number (specific emitter identification); demonstrate multifunction sensor and mapping functions using other than normal SIGINT sensors; demonstrate SIMDIS high-fidelity T&E display to a remote site; demonstrate PC-based EW planning/analysis tool prototype.

FY2003: Demonstrate warfighter RF collection system co-resident on surrogate RF platform; demonstrate linking of processing and dissemination and visualization of collocated data at all levels of intended users with 2-min updates; demonstrate with current tactical radios and a surrogate future digital radio the ability to synchronize and optimize use of the radio multifunction capability; produce position location with less than a 50-m accuracy.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LTC C. FRY, USA TSM Ground	CAPT Dan GAHAGAN, USN ONR/EWO	Mr. Lou LOME DUSD/S&T/SS
Mr. Bill HELIN, USN FIWC	Mr. Rob SAUNDERS SARD/TT	

SE.82 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602270A	442	1.4	1.5	1.5	0.5	0.0	0.0
0602270A	906	2.0	4.2	4.2	0.5	0.0	0.0
0602270N	00000	0.9	1.0	0.9	0.0	0.0	0.0
0603270A	K15	0.7	1.2	3.4	0.7	0.0	0.0
0603270N	R2090	0.3	0.3	0.2	0.0	0.0	0.0
	DTO Total	**5.3**	**8.2**	**10.2**	**1.7**	**0.0**	**0.0**

SE.83 Multisource Integration and Data Fusion

Objectives. Develop platform-level system integration technologies such as adaptive and reconfigurable interfaces and protocols to facilitate efficient onboard and offboard source information fusion, management, and distribution. Initially, a multisensor/source technology testbed (COTS-based) that is representative of a Navy E2C airborne early warning aircraft will be established to develop, exercise, and validate integrated architecture and system concepts including fusion and correlation of tactical datalinks, information networks, and satellite communication sources. The testbed will also embed fusion technologies addressing the combat identification needs of the EP–3 aircraft and sensor resource manager technologies being developed to improve the Aegis SPY1–D radar sensor performance in theater missile defense operations. The testbed will be implemented as a critical technology building block for ODUSD's Smart SensorWeb and will include development of data and signal processors and algorithms for automated resource management processing and automated decision aids to enable efficient real time acquisition, routing, and display of time-critical information to theater users. The testbed will be developed based on a plug-and-play architecture so that related DoD agency, service, and industry developments such as the Dynamic Airspace Management System, Adaptive Courses of Action ACTD, and the Surveillance and Reconnaissance Manager can be readily implemented and evaluated as they become available.

Payoffs. Technologies developed and demonstrated within this DTO will lead to significant gains in operational capability and efficiency. Multisource integration and fusion at the platform and theater level is fundamental to realization of total force interoperability. The technologies developed and matured within this DTO will have substantial payoff in reducing operator workload, improved situational awareness, and improved reaction time. Fused, correlated, and filtered information available in real time via connectivity to networks such as the conceptual Smart SensorWeb will provide decisionmakers at all levels of command with access to information that is critical to timely and successful execution of warfighting objectives.

Challenges. Algorithm and signal processing technologies to support multisource/multisensor integration, and data fusion, even at the platform level, are currently in the early stages of R&D and require significant maturation and risk reduction. Focused designs emphasizing efficient and scalable system architectures are a significant challenge at the platform combat system level, and present even greater challenges as networks such as the Smart SensorWeb are developed and fielded. The Smart SensorWeb will provide the warfighter with a common vision of Web-centric sensors that cover air, ground, sea, and undersea. Development of reconfigurable interfaces and protocols to facilitate accessibility to emerging network and datalink technologies is a driver in this DTO.

Milestones/Metrics.

FY2000: Complete E2C integrated combat system architecture and interface definition. Include hooks for interface to Smart SensorWeb.

FY2001: Initiate development of full-up multisensor integration fusion processor and resource manager for E2C combat system. Demonstrate automated cueing with track update occurring in less than 0.5 s on high-speed targets.

FY2002: Complete development and SIL evaluation of multispectral imaging (MSI) fusion and resource management processor and algorithm suite. Demonstrate 50% reduction in redundant tracks.

FY2003: Complete mountaintop demonstration of 95% reduction in false or redundant tracks. Install the MSI system into the E2C/C–130 testbed aircraft and conduct full-up system evaluation. Transition to PMA–231.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT Lee LILLY, USN PEO–T, PMA–231	Ms. Mun Won FENTON ONR 31	Mr. Jeff PAUL ODUSD(S&T)/SS

SE.83 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602232N	00000	2.5	2.5	2.5	2.5	0.0	0.0
0602270N	00000	0.4	0.4	0.4	0.5	0.0	0.0
	DTO Total	**2.9**	**2.9**	**2.9**	**3.0**	**0.0**	**0.0**

SE.84 Platform-Independent Open Systems Architectures

Objectives. Develop and demonstrate open systems architectures/technologies that facilitate the physical and functional integration of advanced sensors, processes, and digital combat information on and across air platforms (manned and uninhabited); maintain compliance with the joint technical architecture and promote horizontal technology integration with ground vehicles, ships, and space vehicles; address legacy and future platforms; emphasize the system-level architectural designs, particularly the integration of onboard and offboard sensors with other platform functions; ensure that transmitted and received data are secure and that the embedded architectures are sufficiently robust to perform required C^3 functions; and develop the architectures such that information derived from onboard and offboard sources (e.g., satellites, ground control stations, ground-based links, other combat aircraft) is relevant and useful for prosecution of the mission. This DTO will stress commonality, shared resources, software reuse, and market-driven COTS building blocks. Technology advancements include high-speed networks and protocols, integrated RF, 3D imagery in the cockpit, and plug-and-play functionality applications. The embedded architecture will exhibit a level of autonomy for the sharing of information between uninhabited and inhabited systems conducting coordinated missions. This DTO integrates advanced technology improvements from both the embedded and the external architectures for sensors, processors, and information networks. This technology has specific application to Comanche, Longbow Apache, other legacy rotorcraft; to the Joint Transport Rotorcraft via the Army Rotorcraft Open System Avionics program; to the F–18, EA–6B, E2C, and mission planning systems via the Navy AAS program; and to the AF/DARPA/Navy UCAV program.

Payoffs. Payoffs include an architecture(s) that can be easily reconfigured for multiple missions, is applicable to several platforms, is COTS-based, uses shared resources, avoids technology obsolescence, provides the architectural capability to accommodate increased functionality such as the OSD initiative Smart SensorWeb, and that can be readily upgraded. A 30% reduction in volume and weight will be realized through the use of common modules and multifunction RF systems along with reduced operator workload and training due to the fusion management and presentation of information. Projected life-cycle-cost reductions are 30%–40%.

Challenges. Technical barriers include development of an open system architecture that can endure numerous technology innovations and component obsolescence while enabling cost-effective performance improvements and development of high-speed, multifunction, unified network and wide-bandwidth network components. Other challenges include real-time object request broker operating systems and software reuse, real-time fusion of onboard/offboard imagery (particularly 3D) plug-and-play capability with an open architecture design to permit increased functionality into legacy platforms including fixed-wing and rotorcraft, and seamless interaction between embedded architectural components (processors, sensors, data networks, etc.) and the external architecture (sensors, datalinks, ground stations, combat aircraft, etc.) to meet rigid timeline requirements.

Milestones/Metrics.

FY2000: Complete the indexing algorithms and provide open system power specifications for review and acceptance as IEEE standard/specification. Develop international program for open system architecture for integrated RF system. Define rotorcraft avionics architectural requirements; develop a technical reference architecture (initial version); and conduct laboratory evaluations of a 16- x 16-port fiber channel high-speed interconnect switch. Demonstrate 3D visualization on avionics-like processor.

FY2001: Demonstrate a robust 3D visualization capability on an avionics processor in real time in a manned flight simulator. Design a COTS-based open avionics architecture that increases plug-and-play capability by 70% and reduces platform networks and components by 40% and line-replaceable-unit count by 66%. Host and run display software in real time using COTS-based operating system portability.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT Ken KRECH, USN PMA–234	Mr. John KINZER ONR 351	Dr. Jasper LUPO ODUSD(S&T)/SS
CAPT Richard MOEBIUS, USN PMA–233	Mr. John OSTGAARD, USAF AFRL	
	Mr. Bruce TENNEY, USA AMCOM	

SE.84 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602211A	47A	0.7	0.7	0.0	0.0	0.0	0.0
0603217N	R0446	3.4	3.5	0.0	0.0	0.0	0.0
	DTO Total	**4.1**	**4.2**	**0.0**	**0.0**	**0.0**	**0.0**

SE.84 Non-S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0902198	C2507	0.3	0.0	0.0	0.0	0.0	0.0
UNKNOWN	Industry	1.2	1.0	0.1	0.0	0.0	0.0
	DTO Total	**1.5**	**1.0**	**0.1**	**0.0**	**0.0**	**0.0**

SE.85 EO Target Detection, Location, and Noncooperative Identification

Objectives. Develop and demonstrate an integrated, low-cost, multifunction LADAR laser target identification precision targeting capability with IR detection to provide pilots and soldiers with positive, timely, and reliable target detection, location, and identification information at survivable standoff distances for ground-to-air and ground-to-ground missions.

Payoffs. Current EO targeting capabilities are both range and performance limited, whereas the projected capability extends targeting to survivable standoff ranges optimized for current and future weapons, and provides greatly enhanced detection and noncooperative identification needed for both optimized human interface and automated target detection, location, and ID. An additional objective is to reduce fratricide by providing an integrated capability for noncooperative ID of both ground and air targets. Emphasis on common and modular EO system/subsystems and a P^3I upgrade approach to existing targeting systems should provide both commonality and higher production runs to reduce engineering and life-cycle costs and address key affordability issues.

Challenges. Challenges include extending ranges for target ID, lowering power requirements, and lowering systems costs as compared to currently fielded systems. This program will leverage current and future R&D activities in order to integrate the following program technologies into one multifunction EO system. The system includes laser burst illumination, short-wave IR sensor (SWIR), uncooled long-wave IR sensor, and automated target recognition (ATR) technologies. Specific programs to be leveraged include the Low-Power Uncooled IR STO, the Micro Eye-Safe Laser Sources STO, and the Solid-State Near IR STO; and will impact the future Cost-Effective Targeting System for Unmanned Ground Vehicles (UGV) program. The future Cost-Effective Targeting System will improve range-gated imaging capabilities for ground applications. The system will utilize the low-power uncooled IR sensor to detect targets and aim the system using the ATR to determine priority for active range gating SWIR imaging with the micro eye-safe laser providing illumination. The ATR will then use the range-gated imagery to assess target ID at extended ranges. The program is designed for technology integration and insertion. Demonstrations of this DTO will be in a ground platform environment. Ground experiments will demonstrate standoff target ID at greater than 3.5 km using an active sensor suite with 1/5th the cost of the HTI FLIR.

Milestones/Metrics.

FY2000: Initial demonstration of improved gated SWIR receiver with micro-laser source.

FY2001: Engineering trades and hardware design. Preliminary design review. Demonstrate an electron-bombarded CCD image with greater than 20% quantum efficiency.

FY2002: Critical design review. Demonstration of integrated active illuminator with uncooled FLIR for ground-based target acquisition to 3.5 km.

FY2003: Demonstration of automatic target detection and active ID (manual) using uncooled FLIR/micro-laser/SWIR camera in UGV.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Jim STONE, USA USAIS	Dr. Don REAGO, USA NVESD	Mr. Jeff PAUL ODUSD(S&T)/SS

SE.85 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0602709A	H95	1.0	1.1	1.0	0.0	0.0	0.0
0603710A	K70	3.0	4.1	6.0	4.1	0.0	0.0
	DTO Total	**4.0**	**5.2**	**7.0**	**4.1**	**0.0**	**0.0**

SE.86 Adaptive Integrated Optoelectronics for Sensors and Communications

Objectives. Develop key optoelectronic component and integration technologies to demonstrate adaptive compact optical array modules for both emitters and detectors providing enhanced communication, control, and awareness of the battlefield; develop agile beam-steering laser scanning modules that are compact, ultra-light, robust, and capable of being rapidly and accurately steered; and develop detector-receiver arrays with very high time resolution that can be used to adaptively extract range information to produce 3D images of targets in clutter from long standoff distances.

Payoffs. The payoff in adaptive laser scanning is to create a new capability incorporating reduced volume and weight with increased functional throughput for low-power, point-to-point communication. This technology will allow gimbaled and turret-mounted lasers with a unit that is 30X smaller in volume and weight and has 10X the throughput, particularly for multiple targets. The 3D imaging capability will extend target identification 2X to 5X beyond capabilities of current systems and improve by an order of magnitude the acquisition and identification of partially obscured targets and targets in clutter, with corresponding improvements in kill rates and decreases in friendly fratricide. Also being considered is the application of beam steering to target designation and missile defense, which will offer significant payoffs as well as additional demanding performance requirements.

Challenges. A key challenge for beam steering is to meet the necessary performance in optical steering using microstructure approaches that are most likely to enable the compact size of the overall unit. Advances in patterned liquid crystals, optical MEMS, micro-optics, or polarization switching materials may be required. For 3D imaging, the key challenge is in the development of a detector-receiver that is simultaneously high-speed (sub-nanosecond) and can be fabricated in arrays up to 128 x 128.

Milestones/Metrics.

FY2000: Demonstrate ability of micromachined structures to meet overall needs for compact high-bit-rate (greater than 10X) steered-beam communication systems. Investigate near-IR materials with spectral response greater than 1.54 µm. Develop and demonstrate 3D imaging array with range resolution goal of less than 6 in and gain/BW product of 30–50 GHz.

FY2001: Fabricate and evaluate beam-steering emitters and receiver strategies for rapid establishment of secure communication links. Demonstrate 3D 128 x 128 high-range resolution (less than 6 in), imaging sensor(s) having a sensor gain of 1,000, response uniformity less than 20%, and gain/BW product greater than 30.

FY2002: Complete downselection among competing beam steering, emitter, and detector alternatives. Complete design of architecture and definition of interface standards. Demonstrate stability of integrated components for steering optical beams. Demonstrate 128 x 128 array for long-range target identification (up to 7 km).

FY2003: Fabricate prototype steered agile beam system and verify performance.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. M. TINNEY USAF/AIA	Dr. Robert LEHENY, USAF DARPA/MTO	Dr. Jasper LUPO ODUSD(S&T)/SS

SE.86 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603739E	MT–15	7.0	14.0	14.0	6.0	0.0	0.0
	DTO Total	**7.0**	**14.0**	**14.0**	**6.0**	**0.0**	**0.0**

SE.87 Integrated Microfluidic Chips

Objectives. Develop critical integrated microfluidic chip technologies that enable a wide variety of bio-fluidic "lab-on-a-chip" applications. Potential focus applications for these technologies may include compact biofluidic microsystems for assessment of the warfighter's medical condition using samples of their body fluids, chip-scale microsystems for detection of invading pathogens and for presymptomatic diagnostics, and biodetector chips for use in wide-area distributed sensor networks. The microfluidic technologies under development for biofluidic chips will also enable integration of a wide variety of components that will enable diagnostics, rapid detection, and, potentially, treatment in single chips. Specific chip-scale technologies to be developed include sample collection, sample preparation, storage of drugs/reagents, reconstitution of reagents/drugs, and direct antidote delivery.

Payoffs. The development and demonstration of biofluidic chip technologies will lead to ubiquitous deployment of miniaturized biodetectors for various military applications. Examples of these payoffs include unobtrusive monitoring of the warfighter's physiological conditions for real-time detection of exposure to chemical/biological warfare agents, identification of infectious diseases, monitoring of battlefield vital signs, and the provision of indicators to assist in triage and decontamination efforts. These chip technologies are also the enablers for wide-area distributed biosensors. This technology will allow these functions to be performed in a package that is extremely compact and unobtrusive.

Challenges. The heterogeneous integration of materials is a major challenge to develop high-performance, low-cost biofluidic chips. Packaging challenges include on-chip storage and reconstitution of the reagents compatible with the microfabrication process. The on-chip integration of reliable low-power microvalves and micropumps is a difficult task. Ultrasensitive and rapid detection are currently achieved by fluorescence assays that require new approaches to optics to reduce size. Another challenge is to develop amplification technologies, including the sensing of cascade reactions of the immune system. Finally, low-power consumption of the microfluidic system is a must and may require innovative solutions such as harnessing energy from the surrounding environment.

Milestones/Metrics.

FY2000: Design and simulate biofluidic chips. Develop microfluidic architecture including the microfabrication process, the microfluidic assay and protocol, and the specifications of each component to achieve integrated device-level performance goals. Design on-chip reagent storage and reconstitution. Design chip interface to body fluids.

FY2001: Develop closed-loop biofluidic chips to regulate reaction rates and precise dosage of chemicals/drugs/reagents/enzymes. Demonstrate in vitro manipulation (pump/valve/sense) of biofluids in microfluidic components.

FY2002: Integrate individual components on biofluidic chips. Regulate on-chip, in vitro cellular transduction pathways. Demonstrate fluid sampling/delivery interface.

FY2003: Test and validate integrated biofluidic chips. Demonstration of host-based assay biofluidic chips.

Customer POC	Service/Agency POC	USD(A&T) POC
Lt Col Mike URBAN, USAF CENTCOM	Dr. Abraham LEE DARPA/MTO	Dr. Susan TURNBACH ODUSD(S&T)/SS

SE.87 S&T Funding ($ millions)

PE	Project	FY00	FY01	FY02	FY03	FY04	FY05
0603739E	MT–12	6.0	10.0	10.0	10.0	0.0	0.0
	DTO Total	**6.0**	**10.0**	**10.0**	**10.0**	**0.0**	**0.0**