DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the first fiscal year (FY) 2001 solicitation (2001.1). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included followed by full topic descriptions. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

Please note that **1 original and 4 copies** of each proposal must be mailed or hand-carried. DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

* DARPA Phase I awards will be Firm Fixed Price contracts.

* Phase I proposals **shall not exceed $99,000**.

* DARPA Phase II proposals must be invited by the respective Phase I technical monitor (**with the exception of *FastTrack* Phase II proposals – see section 4.5 of this solicitation**). DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000.

* It is expected that a majority of the Phase II contracts will be Cost Plus Fixed Fee.

Prior to receiving a contract award, the small business **MUST** be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-800-334-3414 or internet: http://ccr.edi.disa.mil. The small business **MUST** also have a Commercial & Government Entity (CAGE) Code. This code is part of the CCR registration package. For information, call 1-888-352-9333 (Press 3) or 1-888-227-2423 or internet: www.ccr.dlsc.dla.mil.

The responsibility for implementing DARPA's SBIR Program rests with the Facilities and Administration Directorate (FAD). The DARPA SBIR Program Manager is Ms. Connie Jacobs. DARPA invites the small business community to send proposals directly to DARPA at the following address:

DARPA/CMO/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 526-4170
Home Page http://www.darpa.mil/sbir/

SBIR proposals will be processed by DARPA CMO and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

* Cost proposals will be considered to be binding for 180 days from closing date of solicitation.

* For contractual purposes, proposals submitted to DARPA should include a clear statement of work to be accomplished. It is expected that the contractor's proposal will be included in the contract by reference and will be legally binding.

* Successful offerors will be expected to begin work no later than 28 days after contract award.

* For planning purposes, the contract award process is normally completed within 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

The DOD SBIR Program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. **DARPA encourages Fast Track Applications between the 5th and 6th month of the Phase I effort. Technical dialogues with DARPA Program Managers are encouraged to ensure research continuity during the interim period and Phase II. If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding will not exceed $40,000.**

DARPA SB011-001 TITLE: Advanced Packaging Technology for RF MEMS

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop innovative Radio Frequency (RF) packaging technology with minimal loss to support integration of RF micro-electromechanical system (MEMS) devices into systems.

DESCRIPTION: DARPA and others have invested heavily in the development of MEMS technology in recent years. Several commercial products in the area of optical and inertial components are readily available from this investment. However, RF MEMS technology, while generating excellent research, has not yet offered commercial products. One area of technology development that requires further research is the innovative packaging of RF MEMS devices (to include electromagnetic interference (EMI) shielding, loss-less connectors, corrosion resistance, and military ruggedness for shock and humidity conditions in a single package). Packaging RF MEMS components is a nontrivial task that will require innovative concepts to take advantage of the performance improvements exhibited by MEMS technology. Currently, RF probe stations are required to characterize the performance of these devices. RF probes sufficient for testing from K through W band are expensive and test results are dependent on probe placement. Prior to practical implementation of RF MEMS components, innovative and advanced packaging concepts must be satisfactorily addressed. Packaging issues must be researched and developed to retain the advantages of low insertion loss and high reliability for a minimal cost. The packaging must address the small size of RF MEMS components and handle the moving parts without degradation of performance or increased temperatures. Switches hold promise as the first RF MEMS devices to have the opportunity to be commercialized. To date, RF MEMS switch development has not considered the overall packaging of the device for commercialization potential. Packaging issues to be addressed include material choices, cost, thermal management, EMI shielding, signal losses, and electrical noise due to the integration of the basic switch with the packaging interface. The size of the final packaged device should be comparable or smaller than existing commercially available non-MEMS RF components. High priority is placed on solutions leading to hermetically sealed components to mitigate corrosion for use in harsh military environments. Corrosion mitigation also improves lifetime and performance reliability. Of interest to the Army missile community is the development and integration of a high performance (fast acting, low loss) packaged RF MEMS switch for frequencies from K through W bands. Commercial applications at significantly lower frequencies of operation also abound in the automotive, telecommunication, and aviation areas. It is envisioned that some parameters to address the packaging issues outlined above will be frequency-independent whereas others will be frequency-dependent.

PHASE I: Design and analyze unique packaging concepts for RF MEMS switch to include a trade-space study of the various parameters and metrics. Also, demonstrate proof-of-concept for a packaged switch at K band compatible with existing RF testing/measurement equipment. Demonstrate that switch packaging offers limited degradation of performance compared with probe measurements.

PHASE II: Fabricate and test a high performance packaged RF MEMS switch for Ka band operation. Also, provide technology roadmap for implementation through W band. AMCOM will provide facilities, at no cost to the Small Business, for independent testing of packaged switches.

PHASE III DUAL USE APPLICATIONS: Advanced packaged RF MEMS components have a plethora of opportunities for systems insertion, military and commercial. Military applications at K through W band include RF seekers and ground-based radars. High performance packaged RF MEMS switches offer the promise of reduced component count and improved range of operation in these systems. Commercial applications at lower frequencies include wireless telecommunication networks, automotive electronics, and avionics systems.

KEYWORDS: MEMS Packaging Technology, RF MEMS, Missile Seekers, Radar.

DARPA SB011-002 TITLE: Tools For Predictive Assessment of Structural Integrity of Complex Mechanical Systems

KEY TECHNOLOGY AREA: Materials/Processes

OBJECTIVE: The goal of this program is to link future capability prediction (prognostics) with salient features at the materials level, especially to the damage accumulation and defect initiation phenomena for a particular material. We must be able to interpret natural signatures and associate them with changes in features at this microstructural level. It aims to extract information (using new or adapting existing tools) on the state of the material and transferring this information to a prognostics system. It is intended that this state of awareness be based on physical phenomena occurring at the materials/microstructural level in a structure and detection of early stages of fracture, fatigue, and other damage as well as other structure-sensitive properties of materials of construction. It is necessary therefore, to include work on linking such procedures, methods, and tools with vibration, thermal, or other 'natural' signatures of mechanical components, subsystems, or systems. Exploitation of efficient and robust mathematical techniques for interpreting the data (however gathered) arising from the underlying physical phenomena and natural signatures is desired.

DESCRIPTION: The performance of complex mechanical systems (such as aircraft, missiles, ships, and ground combat vehicles) ultimately depends upon the basic properties of the materials of their construction. The properties of a particular material are defined by its microstructure at a specific time, which may vary as a result of purposeful modification, aging/degradation, or unexpected damage. These changes must be taken into account in a precise manner in order to assess the immediate future capability of the system. "Field friendly" prognostics procedures, methods, and instruments are needed in order to characterize the state of materials used in systems, to measure key information about materials parameters in their operating environments, and to directly link and display information so derived for predictive assessment of the structural integrity and/or remaining utility of a fielded system. This set of technology advances may very well alleviate the need for frequent, very expensive scheduled maintenance schedules, as well as markedly increasing the readiness of mission-capable systems. In this program, the focus of attention must be on linking data gathered at the materials level with interpretations of vibration and other natural signatures of systems in service in order to predict the future utility of any specific system under expected loading conditions.

PHASE I: Demonstrate techniques and tools that can be used in the field to assess the state of structural materials and that can be linked to natural signatures of systems in order to predict immediate future mechanical capability. This phase can focus upon experimental or prototype materials specimens in representative configurations.

PHASE II: Demonstrate field-compatible prognostics systems for assessment of structural integrity that operate with low power, low volume, low weight, and efficient signal processing capabilities and that are applicable to existing military systems. Prognostics tools demonstrated in this phase must be based upon linkages between materials level phenomena/data and larger scale signatures of systems or parts thereof. Demonstrate capability to detect hidden damage in “blind tests” both in experimental and actually used configurations.

PHASE III: DUAL USE APPLICATIONS: Successful development will result in systems and tools with multiple applications in military aircraft, ships, helicopters, and other vehicles. Commercial applications can be found, among others, in the aircraft industry, heavy plant and machinery, chemical plants, and power generation systems.

KEYWORDS: Materials Fracture, Damage Accumulation, Non-Destructive Evaluation, Prognostics.

REFERENCES:
1. Hansen, Robert J., David L. Hall, G. William Nickerson, and Shashi Phoha. “Integrated Predictive Diagnostics:An Expanded View.” ASME Journal. New York: American Society of Mechanical Engineers, 1996.
2. Hansen, R. J., D. L. Hall, and S. K. Kurtz, ``A New Approach to the Challenge of Machinery Prognostics, " Transactions of the ASME, vol. 117, pp. 320-325, April, 1995.
3. Byington, C. S. and G. W. Nickerson. "Technology Issues in Condition-Based Maintenance." 7th Annual Predictive Maintenance Technology Conference, December 5, 1995. Reprinted in P/PM Technology Magazine, Vol. 9, Issue 3, June 1996.
4. Favro, L. D., et.al. "Infared Imaging of Defects Heated by a Sonic Pulse", R*eview of Scientific Instruments,* vol 71, number 6, pp 2418-2421, 2000.

DARPA SB011-003 TITLE: High Temperature Shape Memory Alloys for Useful Devices

KEY TECHNOLOGY AREA: Materials/Processes, Air Platforms, Ground and Sea Vehicles, Weapons, and Space Platforms

OBJECTIVE: To develop shape memory alloy (SMA) materials with high transformation temperatures (austenite start temperatures in the range of 150-300^{o}C and martensite finish temperatures in the range of 90-120^{o}C or higher are desired) while maintaining the forces and strain capabilities of conventional SMAs along with low hysteresis during the shape memory effect; and to develop appropriate processes for making useful forms cost effectively for actuator devices with application in elevated temperature sections of aircraft, ground vehicles, space platforms, missiles, and various types of engines.

DESCRIPTION: Shape memory alloys (SMAs) are an important group of smart materials that work via a temperature-induced microstructural phase change in the material. Large shape-memory effects occur in certain intermetallic compounds with martensitic phase transformations. At least 18 known alloy systems exhibit the shape memory effect, but at present, only 3 are of commercial importance: nickel-titanium alloys, copper-zinc-aluminum, and copper-aluminum-nickel. Such metals are specially deformed in a relatively low-temperature martensitic state but return to their original shape when transformed to the higher temperature austenitic state. SMAs actuation mechanisms and control approaches can be fairly simple in design and part of the load bearing structure itself, an advantage over other types of actuators. However, because of their slow time required for cooling, they are best suited for low-frequency applications, on the order of a few hertz or less. SMAs have been used in many temperature-sensitive applications such as fuel control valves, surgical equipment, and aerospace equipment [e.g., Ref 1]. Significant research has been directed toward demonstrating these alloys in shape-changing structural components, e.g., various types of control surfaces including aircraft wings and engine inlets [e.g., Ref 2-4]. One of the key factors limiting more widespread application has been the relatively low temperature capability of existing materials and devices. Some new alloys, such as Ni-Ti-Pd alloys, have been shown to offer some promise to greatly improve the high-temperature capabilities of these materials by significantly raising the austenite start temperature (to the 150 to 250°C range and possibly higher) as well as the martensite finish temperature (to the 90 to100°C range) [Ref 5-7]. SMA actuators exhibit relatively large actuation force (recovery force) and high strain (recovery strain up to 8%, although 4% is the more typical, useful value) output. Current austenite and martinsite start and finish temperatures can be adjusted by changing the material composition: austenite start temperatures of the binary alloys are in the -100 to +100°C range while martensite finish temperatures can be in the range of <-100 to about 35°C. Typical forms include wires, rolled foils or sheets, and torque tubes; thin films for micro-scale devices are in the developmental stage.

PHASE I: Determine appropriate compositions for SMAs with higher transformation temperature capabilities: a minimum austenite start temperature of 150°C is desired with higher start temperatures up to 300°C or more while maintaining force and strain capabilities of lower temperature materials and low hysteresis during the shape memory effect; identify an appropriate application and develop several preliminary designs for prototype actuators; demonstrate feasibility of manufacturing process steps to make the necessary product forms for the prototype devices; and demonstrate feasibility of the actuators via analysis and selected critical experiments.

PHASE II: Refine actuator designs and manufacturing processes; build and test several actuator devices for an application; demonstrations should show significant system performance improvement or an enabling capability via use of these high-temperature devices.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR will enable unique system benefits in a variety of military systems. It can be applied equally as well to commercial ground vehicles, space platforms, engines, and other commercial products where a higher temperature actuator device is needed.

KEYWORDS: Shape Memory Alloys, Ni-Ti-Pd Aloys, Autenite Start Temperature, Martensite Finish Temperature, Transformation Temperatures, Actuators.

REFERENCES:

1. L.M. Schetky and B.M. Steinetz, "Shape memory alloy adaptive control of gas turbine engine compressor blade tip clearance," *Industrial and Commercial Applications of Smart Structures Technologies*, Paper 3326-36, Vol. 3326, Society of PhotoOptical Instrumentation Engineers (SPIE), Bellingham, WA, 1998, pp. 346-354.
2. M.A. Hopkins, J.P. Dunne, E.W. Baumann, and E.V. White, "Adaptive Fighter Engine Inlet," *Proceedings of the 40th Structures, Structural Dynamics, and Materials Conference*, AIAA-99-1512, AIAA, Reston, VA, 1999.
3. A.P. Jardine, J. Bartley-Cho, and J. Flanagan, "Improved Design and Performance of the SMA Torque Tube for the DARPA Smart Wing Program," *Industrial and Commercial Applications of Smart Structures Technologies*, SPIE 3674-29, Vol. 3674, Society of PhotoOptical Instrumentation Engineers (SPIE), Bellingham, WA, 1999, pp. 260-269.
4. C. Martin, J. Bartley-Cho, J. Flanagan, and B.F. Carpenter, "Design and Fabrication of Smart Wing Wind Tunnel Model and SMA Control Surfaces," *Industrial and Commercial Applications of Smart Structures Technologies*, SPIE 3674-28, Vol. 3674, Society of PhotoOptical Instrumentation Engineers (SPIE), Bellingham, WA, 1999, pp. 237-248.
5. P. Lindquist and C.M. Wayman, in *Engineering Aspects of Shape Memory Alloys*, T.W. Duerig, K.N. Melton, D. Stockel, and C.M. Wayman, editors, Butterworth-Heinemann: London, U.K., 1990, p. 58.
6. J. Van Humbeeck and L. Delaey, in *The Martensitic Transformation in Science and Technology*, E. Hornbogen and N. Jost, editors, DGM Informationsgesellschaft, 1989, p. 15.

7. J. Van Humbeeck, D. Reynaerts, and J. Peirs, "New Opportunities for Shape Memory Alloys for Actuators, Biomedical Engineering, and Smart Materials," *Materials Technology*, Vol. 11, No. 2, 1996, pp. 55-61.

DARPA SB011-004 TITLE**:** Self-Cleaning Dynamic Adhesive Materials

KEY TECHNOLOGY AREA: Materials/Processes

OBJECTIVE: Develop novel adhesive materials capable of generating tunable and controllable adhesive forces and self-cleaning properties that can be demonstrated on varying surfaces. These materials may be patterned on unique architectural biomimetic principles and/or novel biomimetic chemistries.

DESCRIPTION: Many biological systems, such as skinks, geckos, and frogs show unusual abilities to modulate adhesive forces in order to hold onto and rapidly climb a number of challenging surfaces. In many cases, biological systems employ novel materials and/or structures in their feet and legs that dynamically modulate the necessary forces to accommodate the ability to rapidly attach and detach from a number of surfaces while avoiding falling or fouling. The purpose of this solicitation is to explore the development of a new generation of materials that may be inspired by these unique systems in order to create a novel self-cleaning, dry adhesive that could be robustly and dynamically adhesive. These could be widely useful for a variety of Defense applications including robotics, micro-air vehicles, and adhesive and antifouling applications. Initial efforts to design such a material could, but are not required to, consider the novel microstructures employed by biological systems and/or unique materials and chemistries that might emulate the biological principles that demonstrate these unique traits and create adhesive forces of 100N over a cm^2 area. Switching or modulation of the force might be generated through dynamically altering the physical structure of the material through morphological changes of the material on attachment or detachment and could include the summation of small forces (uN) in hair like or other structures. Modulating adhesive properties through novel chemistries that might self-decontaminate through modifications to either bulk or chemical surface properties to create a dynamic coating could also be considered. These could include such strategies as modulating material properties through conformational changes in the material induced by physical state (e.g., temp, light, electrical energy) or chemical modifications.

PHASE I: The first phase will require the feasibility and design of self-cleaning dry adhesives capable of operating over 1-100N over surface areas of 1 mm to 2 cm. These properties may be designed through either physical (microstructure) alterations or chemical modifications. The designs should include demonstrations of self-cleaning properties of the adhesive on contaminated surfaces.

PHASE II: The second phase will consider methods to modulate the adhesive properties and create a dynamic material that can rapidly alter its adhesive properties, inspired by the rapid alterations during attachment and detachment of sticky feet. Successful Phase II proposals will fabricate and demonstrate a novel self-cleaning dry adhesive that can rapidly (usec to msec) modulate force (1 to 200N) over a large surface area (mm to cm). The self-cleaning properties would be demonstrated over fouled surfaces in which particulate contamination is present.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in high-end commercial adhesive markets where dynamic force characteristics and self-cleaning principles are dominant.

KEYWORDS: Adhesives, Self-cleaning, Biomimetics.

REFERENCES:
1. Adhesive force of a single gecko foot-hair. Kellar Autumn, Yiching A. Liang, S. Tonia Hsieh, Wolfgang Zesch, Wai Pang Chan, Thomas W. Kenny, Ronald Fearing & Robert J. Full. Nature 405, 681 - 685 (2000).

DARPA SB011-005 TITLE: Piezoelectric Single Crystal Applications

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Devise and fabricate practical devices for defense and civilian applications that exploit the extraordinary electromechanical properties (high coupling: 90-95%; high strain: ~ 1%) of single crystal relaxor piezoelectrics.

DESCRIPTION: Near the onset of 1997 came the discovery that single crystals of certain relaxor ferroelectric (lead magnesium niobate – lead titanate, and lead zinc niobate – lead titanate) materials exhibit extraordinary piezoelectric properties, namely, strains exceeding 1%, and electromechanical coupling exceeding 90% (compared to 0.1% and 70-75%, respectively, in state-of-the-art piezoceramics). Concerted efforts to grow these materials in a variety of forms (bulk, multilayer, fibers, thin films, etc.) now yield materials in quantities and prices suitable for device prototyping. This topic aims to exploit these enhanced electromechanical properties in practical devices. For example, in acoustic transducers the high coupling leads to higher bandwidth (doubled to two octaves or more), while the high strain leads to higher source levels (more than an order of magnitude increase). Actuators employing these materials are more efficient and compact and sensors are smaller and more sensitive. While this topic is open to a broad range of applications, the proposed device should rely on the special properties of the relaxor piezocrystals. In describing the application, proposers should state which property of these crystals is being exploited and why this property is essential to the success of the proposed application. A design—no matter how innovative—that could be realized effectively with conventional materials is not responsive to the intent of this topic. **Endorsement of the importance of the enhanced performance in the proposed device by an Army, Navy, or Air Force device expert is highly desirable.**

PHASE I: Design and demonstrate the feasibility and advantages of a practical device exploiting high-strain, high-coupling relaxor piezocrystals.

PHASE II: Refine the design and demonstrate—in the field—the performance enhancements of the proposed device.

PHASE III DUAL USE APPLICATIONS: Applications in the Defense sector range from Navy sonar, through Army rotorblade control, to Air Force airfoil shape control. In the civilian sector, applications include medical ultrasonics, active machine tool control, and vibration suppression in HVAC systems.

KEYWORDS: Electromechanical Sensors and Actuators, Smart Materials, Vibration Control, Shape Control, Acoustic Transducers, SONAR, Piezoelectrics, Single Crystals, Lead Magnesium Niobate – Lead Titanate, and Lead Zinc Niobate – Lead Titanate.

REFERENCES:
1. S.-E Park and T.R. Shrout, "Ultrahigh Strain and Piezoelectric Behavior in Relaxor based Ferroelectric Single Crystals" J. Appl. Phys., 82 [4], 1804-1881 (1997).
2. S.-E Park and T.R. Shrout, "Characteristics of Relaxor-Based Piezoelectric Single Crystals for Ultrasonic Transucers," IEEE Trans. On Ultras., Ferro. And Freq. Cont., Vol 44, no. 5, 1140-1147 (1997).

DARPA SB011-006 TITLE: Automated Malicious Code Detection

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Research and development of automated mechanisms to detect malicious code before execution or damage is done to the target system.

DESCRIPTION: Malicious code is software that intentionally performs adverse actions against systems executing that software unbeknownst to the system or its operators. It includes terms such as Trojan Horses, worms, viruses, time bombs, trap doors, and covert channels. The need to automatically nullify malicious code is acute for the Defense Information Infrastructure (DII) and National Information Infrastructure (NII) because of increased connectivity and reliance on the Internet, increasing prevalence of mobile code, and likely development, access, and remediation of code by disgruntled insiders and outsiders. Past work for addressing malicious code includes sand boxing, pattern detection (anti-virus software), execution monitoring (virus anomaly detectors), type enforcement, isolation and access control at interfaces (wrappers), proof carrying code (language, compiler level), and code inspection tools. Some of these have problems being effective, are in the stage of initial research, or require significant human interaction. Foundational work exists on after-the-fact detection by observing system behavior (intrusion and anomaly detection); however, such work has been more focused on detecting hacker-type intrusions rather than internal threats posed by malicious code. The main drawback of most existing approaches is that they are after-the-fact, so damage could already have been done by the time the detection works.

PHASE I: Devise software and systems engineering approaches that will automatically (with no human interaction) detect malicious code in systems as a step toward preventing negative effects. Multiple diverse approaches are needed to cover the problem space. They may include, but are not limited to, automatic source code inspection for existing attacks (static), dynamic code scanning, system integrity checking, reverse engineering, code signing, type enforcement, sand boxing, and massively parallel dynamic analysis. It is preferable to detect malicious sleeper and mobile code before it activates and does damage. Extension of pattern-based anti-virus or manual inspection approaches is not called for under this solicitation. Scientific methods and experimentations should be used to provide measures of effectiveness for the investigated approaches.

PHASE II: Develop active response options given categories and types of automatic malicious code detection identified in Phase I. Map appropriate responses to possible detections and provide a method for balancing the negative effect of a response on the system versus consequence of code execution considering both automated and human-reviewed options. Demonstrate the viability of these responses to a series of small experiments that measure the performance of detection and response. Also extend the work of Phase I by refining the most promising techniques as well as identifying the shortcomings of other techniques to determine their viability given further research.

PHASE III DUAL USE APPLICATIONS: Standard business practice for industry already includes virus protection software. This and other internal network auditing software has primed commercial markets for acceptance of a capability for detecting more sophisticated malicious code. Malicious code is acknowledged by industry as a growing problem that they wish to, but cannot properly address. The same is true for DoD, which has an urgent need for a reliable detection capability on its information systems. Therefore work in this area will have a direct conduit for successful Phase III activity.

KEYWORDS: Malicious Code, Anomaly, Anomalous, Malicious Activity, Trojan Horse, Worm, Virus, Time Bomb, Trap Door, Covert Channel.

REFERENCES:
1. Results, Malicious Code ISTSG (Infosec Science and Technology Study Group), initial meeting and first workshop, chartered by the Infosec Research Council (IRC), 15 October 1999, 13 January 2000, http://www.rstcorp.com/irc/, http://www.rstcorp.com/irc/meeting-2.html.
2. Background and example of preliminary anomalous code fragment identification, Reliable Software Technologies, ITS4 tool, http://www.rstcorp.com/its4.

DARPA SB011-007 TITLE: Assurance Technology for High Confidence Software and Systems

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Proposals are requested for innovative research in new technology for achieving high-confidence software and systems.

DESCRIPTION: The principal goal of this research is to provide technology that can (1) increase certainty that operational requirements will be met by complex systems that include real-time embedded components and (2) reduce the cost burden of certifying such systems. Software technology is of particular concern, and the innovations proposed should address allocation and certification of cross-cutting properties (e.g., real-time response, deadlock-freedom, fault isolation) required to achieve safe, secure systems. Innovations are particularly sought in methods that improve certainty while reducing dependence on testing or simulation in post hoc certification steps. Techniques should be emphasized that permit reuse of evidence and reduce the need to exhaustively re-test after software or system modifications. Solutions may include new approaches for software checking and scalable technologies for formal, correct-by-construction software development. New approaches to composing software and evidence, such as aspect-oriented programming and assume-guarantee reasoning, are also relevant. Solution strategies are preferred that have broad applicability but can be tailored for individual application domains. Key issues include: (a) mitigation of effort during software development and certification; (b) completeness of evidence; (c) the range of system issues that can be accommodated; (d) the approach for gathering and composing evidence during development; (e) the scope of the expertise demanded of developers and certifiers; and (f) the effort required to produce evidence that can be used by certifiers in evaluating the overall safety and reliability of embedded and complex systems.

PHASE I: Proposals should indicate how research planning activities will lead, in the Phase II proposal, to approaches that address the above questions. It should also clearly describe: (1) the technology to be developed; (2) the approach for tailoring the technology to the application domain; (3) the approach to deriving and using evidence produced during development to limit the certification burden and improve confidence; and (4) the end-to-end concept for how the technology will be exploited to achieve assurance from development through certification. Appropriate supporting experimental efforts should be carried out in this phase.

PHASE II: The second phase of the research will focus on prototyping the technology support. The prototype should address an assurance problem and should support deriving, composing, and analyzing rigorous evidence that goes beyond test results. It should include exploratory integration of assurance and evidence management technology into realistic prototypes of language, software development, and/or certification-support tools in a domain that can provide useful examples of embedded software and physical system. This phase should yield a framework and limited example for constructing domain-specific certification tools that can be used in an application of military significance.

PHASE III DUAL USE APPLICATIONS: Improvements in commodity software reliability can be expected through the resulting technologies; just as for hardware, this will benefit military systems that depend on COTS. Certification practice that considers joint hardware-software concerns (e.g., fault isolation) will become possible, increasing reliability for both military and civilian embedded systems applications.

KEYWORDS: High-Confidence Software and Systems; Assurance; Certification; Formal Methods; Testing; V&V.

DARPA SB011-008 TITLE: Micro-Architecture Development Tools for Embedded Processing

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Devise micro-architecture hardware and software development tools that enable modification of embedded architecture design parameters as function of size, weight, energy, performance, and time (SWEPT)

DESCRIPTION: Traditional computer architecture development cycles define the application and hardware to be configured by the design engineer. The design parameters are defined in the system development tools and allow iteration until fabrication. The military is pursuing a multi-mission and multi-sensor strategy that will require the use of malleable embedded architectures that need to be reconfigured to efficiently support each unique sensor or mission post fabrication. A new generation of micro-architecture development tools are required to support this changing operational environment. To enable the manipulation of the design parameters, the design space requires innovations in malleable parameterization to include the data width, instruction depth, instruction type, retiming depth, interconnect richness, and control granularity. Even though current design tools are becoming more user friendly, an expert design engineer is significantly involved in the process. The micro-architecture development tools should include a level of automation and self-ware cognition to support the design trade space. The development environment should support micro-architecture simulation, debugging and verification, parameter negotiation, and dynamic optimization and regeneration.

PHASE I: Design micro-architecture hardware and software development techniques and demonstrate dynamic multi-application configurations. Provide various hardware abstractions that coordinate with software programming models.

PHASE II: Demonstrate the capability to actively optimize embedded processor system designs both before and after chip fabrication. Evaluate automated design techniques with expert design engineers.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in interactive multi-media, telecommunications, and any commercial sectors that are reducing the competitive time-to-market for computing devices.

KEYWORDS: Micro-Architecture, Design and Development Tools, Embedded Processing.

REFERENCES:
1. http://www.cs.wisc.edu/~arch/www/

DARPA SB011-009 TITLE: Ultra-Dense Wavelength Division Multiplexing (WDM) Transceivers

KEY TECHNOLOGY AREA: Information Systems Technology and Sensors, Electronics and Battlespace Environment

OBJECTIVE: Devise ultra-dense wavelength division multiplexing (WDM) transmitter and receiver technologies that will enable very high aggregate data transfer rates, while allowing each channel to run at only moderate complementary metal oxide semiconductor ((CMOS) compatible) data rates.

DESCRIPTION: As DOD seeks to rapidly transfer large database, map and targeting files across long and short haul fiberoptic networks, affordable high bandwidth data transfer becomes increasingly difficult to find. Present WDM technology is making very slow progress in terms of increasing channel count by decreasing channel spacing. Rather, the mainstream commercial approach is to extend the operating window of fiber amplifiers and to develop high-speed (high cost) electronics. Ultra-dense WDM is a more revolutionary approach to providing high aggregate bandwidth, yet it offers better affordability through its compatibility with CMOS technology. For this approach to succeed, it will be necessary to develop methods which allow generation of very stable, high channel density WDM transmitters, as well as receivers capable of separating out the individual (though closely spaced) data channels.

PHASE I: Develop novel concepts and designs for ultra-dense WDM transmitter/receiver links, and evaluate feasibility.

PHASE II: Fabricate, assemble and test a proto-type link based on ultra-dense WDM components. Analyze bit error rate, stability and other data link characteristics.

PHASE III DUAL USE APPLICATIONS: The commercial long-haul telco and datacomm markets will make use of this technology. New demand in the metro area network market could also be generated by this technology.

KEYWORDS: Wavelength Division Multiplexing, WDM, Optical Transceivers, Optical Networks.

DARPA SB011-010 TITLE: Card-to-Backplane Optical Interconnects

KEY TECHNOLOGY AREA: Information Systems Technology and Sensors, Electronics and Battlespace Environment

OBJECTIVE: Devise an optical interconnection technology that will allow a card that is inserted into a computer rack to tap into an optical waveguide that resides in the backplane, without requiring a 90-degree out of plane turn by the waveguide.

DESCRIPTION: Optical waveguides in computer backplanes are increasingly seen as the only feasible means to accommodate the large bisection bandwidth of future military processing systems. A major obstacle for backplane waveguides is the present method of card-to-backplane optical interconnection, which requires a 90-degree out of plane turn by the optical waveguide. This approach greatly increases cost of manufacture and degrades backplane reliability. Development of a new card-to-backplane optical interconnection technology is required, such that a repeatable low-loss connection can be made easily, quickly, and affordably.

PHASE I: Devise novel feasibility concepts for robust, low insertion loss, card-to-backplane optical interconnects.

PHASE II: Design, fabricate and test a low loss card-to-backplane optical connector prototype.

PHASE III DUAL USE APPLICATIONS: The optical backplane connectors developed in this project will be used in high-performance military avionics applications and in high-end servers in the commercial market. Each of these applications, both military and civilian, will see substantial benefit from development of these low insertion loss connectors. As lower cost (but higher volume) business and consumer applications increase in bi-section bandwidth, the demand for low loss optical backplane connectors will correspondingly increase.

KEYWORDS: Optical Interconnects, Optical Backplane, Waveguide, Blind Mate Connector.

DARPA SB011-011 TITLE: Next Generation CAD Tools for Gigascale Integrated Mixed Signal System on a Chip

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Development of next generation Computer Aided Design (CAD) tools for the design of gigascale integrated mixed signal system-on-a-chip for military applications.

DESCRIPTION: Shrinking device sizes and higher integration densities are giving rise to a number of new challenges in designing the next generation of integrated electronic and optoelectronic circuits and systems. With the advent of the System-on-a-chip (SOC) technology, it is anticipated that mixed signal (digital, analog and software) and mixed technology (MEMS, fluidics, chemistry, biology, etc.) systems will necessitate new design strategies and methodologies. Current Electronic Design Automation (EDA) tools suffer from a number of limitations in addressing the above issues. Furthermore, it is anticipated that planned commercial investments in the above areas will not satisfactorily address military needs. One example is the analog to digital (A-D) converter for military applications: these systems suffer from severe on-chip electromagnetic (EM) interactions that lead to oscillations and loss of performance. The extreme wideband operation, high clock rates, internal high clock rates, high internal gains and high complexity (in number of transistors) make the design of such systems very laborious and time consuming. DARPA is interested in exploring the feasibility of developing a new generation of CAD tools to enable the design of gigascale integrated mixed signal circuits/systems for military applications. Proposals are sought in the areas of (i) Mixed electronic and photonic systems, and (ii) Mixed signal digital-analog systems for high frequency applications with high complexity (such as A-D converters).

PHASE I: Demonstrate feasibility of a very large-scale integration (VLSI)-like design capability (i.e., a hardware description language (HDL)-based top down design approach) for mixed signal digital-analog and mixed electronic-photonic systems. The proposed design capability should demonstrate improved performance (in terms of overall design cycle time) on the order of 10x to 100x over those of current mixed signal design methodologies. The Phase I effort will develop a plan to transition (in Phase II) the design methodology into either new or existing commercial design environments.

PHASE II: Use the tools developed in Phase I to demonstrate the design of a mixed signal system from concept to fabrication. The design should optimize parameters such as integration density, cross talk (including digital noise effects on analog components), interconnect latency and thermal management. The fabricated chip should demonstrate superior performance as a direct consequence of the improved design tools. The performance data from the system will be used to verify/validate CAD tool predictions. The Phase II effort will also implement the plan (developed in Phase I) to transition the design tools into a commercial design environment. Complete documentation of the data, test cases, test results and the design environment must be delivered upon completion of the contract.

PHASE III DUAL USE APPLICATIONS: This effort will form the groundwork for advanced CAD tools for routine analysis and design of mixed signal microsystems. The development of CAD tools for these applications will address a specific need of the military in being able to design high performance A-D converters affordably. These CAD tools will also have direct applications in two of the fastest growing markets today, (1) Wireless Communication Devices (Mixed Digital/Analog Systems), and (2) Optical Devices consisting of Integrated Electronic/Photonic Systems as well as Micro-Opto-Electro-Mechanical Systems (MOEMS). These CAD tools will enable exploration of novel device concepts and designs, improvements in device performance/reliability and reduction in product time-to-market.

KEYWORDS: Mixed Signal Systems, Digital/Analog Systems, Electronic/Photonic Systems, CAD Tools, VLSI.

DARPA SB011-012 TITLE: Highly Linear, Low Noise Devices for Analog/Digital Converters

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: New super linear high speed technologies that enable 10x to 100x reduction in power to support 100 dB, 100MHz bandwidth receivers and ADCs are sought.

DESCRIPTION: The development of high dynamic range digital receivers and analog/digital converters (ADC's) is limited by the non-linearity and noise characteristics of presently available semiconductor devices. New devices are needed for implementing improved digital receivers building blocks such as low-noise amplifier (LNA), Mixer, and ADC. For example, a high dynamic range ADC that employs a delta-sigma ($\Delta\Sigma$) architecture to achieve a 16 bit (98.6 dB signal-to-noise plus distortion (SINAD)), and a > 100 dB spur free dynamic range over a 100 MHz bandwidth will need improved device technology to enable performance at lower power levels such as 1 watt. Improving performance and reducing power simultaneously is representative of future defense system needs. The amount of power required to achieve either high linearity or fast decisions in support of high dynamic range receivers and ADCs is currently too high in the widely used bipolar technologies. One approach to maximizing dynamic range in active linear components is to increase power consumption in order to reduce distortion terms at increased signal levels, which would provide increased margin above the noise floor. Several factors that are currently limiting this approach, include device scaling limits to achieve maximum power and linearity, low noise figure and residual phase noise. Currently the third order intercept point (IP3) of an amplifier is typically between –10 dB to +10dB of the power consumed. An improved device technology would enable much higher IP3 to Power ratios such as 20dB to 40dB. For example, a highly useful circuit for front-end and $\Delta\Sigma$ loop filter applications would be an amplifier with > 50dbm input referred IP3, a gain > 10dB, and < 1dB noise figure provided at a fraction of a watt of power. There are also many power versus performance issues affecting

ADC sampling and decision circuits. For example, a highly useful circuit for quantizer applications is a comparator (in a >10K transistor IC technology) with <50 fsec output rise-time jitter due to its metastable response while consuming only 5 mW of power. This would enable high performance GHz sampling rate quantizer circuits that consume less than 1 watt of power.

PHASE I: Define device structures and quantify expected benefits.

PHASE II: Fabricate devices and simple circuits (eg., amplifiers) and perform extensive measurements. Document the results and deliver devices and circuits for independent test and evaluation.

PHASE III: Dual Use Applications: As the bandwidth of commercial communication systems continues to grow the need for wideband, high dynamic range analog/digital converters will increase.

KEYWORDS: Analog Devices, Linear Low-Noise Amplifiers, Low Power Devices, Digital Receivers, Delta-Sigma Analog/Digital Converters.

DARPA SB011-013 TITLE: Rapidly Adaptive Intelligent Radar (RAIR)

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop innovative and effective techniques to provide optimal radar detection, multitarget association and identification in the presence of highly nonstationary background interference.

DESCRIPTION: Advanced airborne intelligence, surveillance and reconnaissance (ISR) radars will utilize very high dimensional observation spaces (spatio-temporal, polarimetric, etc.) to maximize theoretical separation of targets from interference, optimize multitarget tracking performance, and enhance combat ID. However, to realize these potential gains, the radar must be able to adapt these degrees-of-freedom (DOFs) “on-the-fly” due to the potentially highly nonstationary nature of interference (clutter, jamming) and target behavior. Hence the need for rapidly adaptive radar signal processing methods to support both GMTI (ground moving target indicator) and SAR (synthetic aperture radar) ISR modes. Conventional methods of adaptation are not expected to efficiently extend to higher dimensional dynamic environments. For example, conventional adaptive spatio-temporal processing based on a direct sample covariance matrix (SCM) approach [1] requires a statistical stationarity assumption almost surely to be violated in practice [2]. The result is either “overnulling” (radar desensitization) or “undernulling” (inadequate interference suppression). Moreover, there is a need to mitigate “singular” interference phenomenon such as large clutter discretes that cannot be directly handled via the SCM approach, or unintentional background “traffic” that can contaminate the secondary data required for statistical estimation [4]. Methods that might be considered to address the aforementioned issues (in no particular order of importance):
The use of adaptive radar waveforms to maximize signal-to-interference-plus-noise-ratio (SINR) and/or optimize target ID in the presence of both additive colored noise and clutter [3].
Using dynamic digital databases that describe the topography, road locations and other characteristics of the area under surveillance to enhance environmental characterization. In particular, knowledge bases might be used to exclude locations that have high probabilities of containing interfering ground traffic and/or clutter discretes leading to “intelligent” adaptation strategies [4].
The use of optimal reduced-rank processing methods to accelerate adaptation [2].
Exploitation of recent advances in minimal sample support methods that can dramatically reduce the amount of secondary data required for adaptation [2]. Methods include (but are not limited to) structured covariance estimation, forward-backward (F/B) smoothing, and eigenbased methods [2].
Robust methods that provide graceful degradation of performance in stressing environments [2].

PHASE I: Postulate and estimate the performance of one or more techniques that could be used to address any or all of the aforementioned design issues. Establish rigorous theoretical performance bounds and conduct requisite numerical simulations in support thereof.

PHASE II: Perform detailed analyses and develop formalized algorithms/methods to precisely quantify the capabilities of the most-promising techniques(s) developed in Phase 1. Demonstrate/validate the performance of the technique(s) using very high fidelity simulations and/or experimentally obtained data. Conduct real-time implementation analyses and mappings onto efficient parallel processing architectures (where applicable). Produce a RAIR prototype signal processing chain capable of supporting technology demonstrations.

PHASE III DUAL USE APPLICATIONS: The techniques that will be developed during this program will be directly applicable to advanced ISR radars and potentially many other adaptive sensor systems (sonar, IR, lidar, etc.). These adaptive radars could also be used in a variety of non-military applications, including monitoring drug trafficking activities and performing border surveillance. Additionally, the underlying methodology that will be developed during this effort could also be extended into a variety of other fields that use high dimensional adaptation and are confronted with analogous challenging scenarios. Applications that have been discussed in the literature include medical imaging, code division multiple access (CDMA) communications systems and echo cancellation.

KEYWORDS: Adaptive Processing, Adaptive Waveform, Spatio-Temporal Adaptive Processing, GMTI, SAR, Minimal Sample Support, Reduced Rank, Knowledge-Based Processing, Nonstationary Interference, Target ID.

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DARPA SB011-014 TITLE: Elimination of Ground Moving Target Returns from the Training Data Set in Adaptive Radars

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop innovative pre-processing techniques to remove radar data samples that contain ground moving target returns from the training data set used for space-time adaptive processing (STAP) algorithms.

DESCRIPTION: Advanced airborne Ground Moving Target Indication (GMTI) radars will utilize spatial and temporal adaptation to reject clutter and interference. Such radars will determine the optimal weights to apply to the multi-channel data for a particular range-Doppler-angle cell by examining the radar returns from other, near-by cells (i.e. the training data set). The underlying assumption is that the training data samples have similar clutter and interference characteristics to the cell under test, but do not contain ground moving target returns. When GMTI returns are present in the training data set, the STAP algorithm will attempt to create nulls at these azimuth angles and Doppler frequencies, which can significantly degrade performance. To prevent performance degradation, pre-processing of the training data samples could be performed to cull out those data samples that have a high probability of containing GMTI returns that will impact the cell under test. It is important that such pre-processing techniques remove only radar data samples that will impact the cell under test, as excising too many data samples will degrade the STAP algorithm's performance against clutter and interference. Methods that potentially could be used to eliminate data samples that might contain GMTI returns include:

1. Examining the spatial / spectral / temporal / statistical characteristics of the training data set to identify samples containing GMTI returns that could affect STAP performance.
2. Using digital databases that describe the topography, road locations and other characteristics of the area under surveillance to aid identifying locations that have high probabilities of containing ground traffic that could affect STAP performance.
3. Estimating the current locations and velocities of ground moving targets by using GMTI target detections from prior radar scans and projecting them forward to the present time.
4. Comparing the current data sample value with previous values from the same location collected during previous radar antenna beam scans.
5. Comparing the current data sample value with previous values from the same location collected on previous passes by the radar.

Advisement: This technology falls under existing Export Control Legislation. Consequently, Foreign Nationals are precluded access to this effort.

PHASE I: Postulate and estimate the performance of one or more techniques that could be used to identify those data samples having a high probability of containing ground moving targets that could affect STAP performance.

PHASE II: Perform detailed analyses and develop formalized algorithms to quantify the capabilities of the most-promising techniques(s) developed in Phase 1. Demonstrate / validate the performance of the technique(s) using simulations and / or experimentally obtained data.

PHASE III DUAL USE APPLICATIONS: Advanced radars that incorporate STAP techniques will be used by the military to detect and track both airborne and ground moving targets. The techniques that will be developed during this program will be directly applicable to these systems. These adaptive radars could also be used in a variety of non-military applications, including monitoring drug trafficking activities and performing border surveillance. The underlying methodology that will be developed during this effort could also be extended into a variety of other fields that use training data sets to control adaptive processing algorithms and that are confronted with analogous scenarios. Applications that have been discussed in the literature include medical imaging, Code Division Multiple Access (CDMA) communications systems and echo cancellation.

KEYWORDS: Adaptive Processing, STAP, GMTI Radar, Training Data Set, Secondary Data Set, Knowledge-Based Processing.

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DARPA SB011-015 TITLE**:** Flash Ladar Advanced Processing

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop advanced laser radar (ladar) signal processing techniques to measure multiple degrees of freedom, including but not limited to range imaging, using a scannerless flash imaging ladar, based upon conventional component hardware technology.

DESCRIPTION: Ladar imaging provides the capability to obtain near-literal optical imagery in day and night conditions, some adverse weather, and typically at longer ranges than passive optics. Furthermore, ladar systems typically possess the capability to make measurements in multiple degrees of freedom, including such properties as range, and perhaps Doppler, polarization or some other target observable. The application of conventional ladar, however, has been very limited, largely due to the inconvenient need to scan a single pixel illumination and detection spot across the target in a raster pattern to form an image. The scanning process requires very long dwell times and stringent gimbal stability. A flash imaging ladar, or laser-illuminated video, system avoids these drawbacks of a conventional ladar by collecting a full frame image in a single laser pulse.[1] It consists of a laser with a spoiled beam, used as an illumination source, and some type of area receiver, such as a charge coupled device (CCD) or focal plane array. There may also be some type of amplification at the receiver such as a conventional image intensifier similar to those used in night vision systems. Flash imaging relieves the stringent gimbal requirements of the scanned ladar and provides much higher data throughput. What is lost is the ability to collect a 3-D image by measuring range, or other degrees of freedom, at each pixel. Technology is being developed to produce "smart pixel" focal plane arrays, which will allow range measurement at each pixel in a flash mode, but these will be expensive devices and for the near future have limited spatial resolution. This solicitation is requesting alternative concepts for the measurement of additional degrees of freedom from a conventional flash-imaging system. The primary interest is in alternate approaches to collection of 3-D imagery, but could include other degrees of freedom as well, for example micro-Doppler vibration analysis, polarization analysis, or atmospheric correction. Approaches will be considered which require minor modifications to the basic hardware described above. However, it is preferred that proposals be limited to those involving variations on collection techniques and signal processing and not require hardware modifications.

PHASE I: Define the details of the proposed technique, including a definition of the parameters to be measured and a design for executing the measurements. Provide evidence for the proposed technique's potential for success, such as system analysis, modeling, or demonstration of initial performance using simulated data.

PHASE II: Develop a prototype suite of software (and hardware as appropriate) to implement the Phase I approach. Use this prototype ladar system to demonstrate the ability to perform flash-ladar exploitation and processing. Evaluate the prototypes performance using real sensor data, and use these results to develop a preliminary design for a fieldable Phase III system.

PHASE III DUAL USE APPLICATIONS: The technology developed under this solicitation would significantly improve combat identification capability for military targeting applications while leveraging sensor hardware available on operational systems. Similar applications exist for non-military security and law enforcement missions. Furthermore, the techniques developed here would be extremely practical to the rapidly growing robotics and machine vision industries to support advanced automated manufacturing. These technologies would allow manufactures new methods for precision assembly without costly replacement of sensor hardware.

KEYWORDS: Ladar, Flash Ladar, Laser Radar, Laser-Illuminated Video, All Light Level TV, 3-D Imaging, Doppler Processing, Polarization, Image Intensifiers, Image Amplifiers, Signal Processing, Image Processing, Combat Identification, Machine Vision.

REFERENCES:
1. An example of a fielded developmental flash ladar system is the Enhance RAnging and SEnsing ladaR (ERASER). Contact Robert Zumrick, AFRL/SNJT, (937) 255-5922, ext 241, Robert.Zumrick@wpafb.af.mil for more information.