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 second fiscal year (FY) 2001 solicitation (FY 2002.1). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although they are unclassified, the subject matter may be considered to be a "critical technology". If you plan to employ NON-U.S. Citizens in the performance of a DARPA SBIR contract, please inform the Contracting Officer who is negotiating your contract. 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,** and may range from 6 to 8 months in duration. Phase I contracts cannot be extended.

- DARPA Phase II proposals must be invited by the respective Phase I technical monitor (with the exception of Fast Track 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. However, DARPA may chose to award a Firm Fixed Price Contract or an Other Transaction, on a case-by-case basis.

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 1-888-352-9333 or Internet: http://www.ccr.dlsc.dla.mil and http://www.ccr2000.com/.

The responsibility for implementing DARPA's SBIR Program rests in the Contracts Management Office. 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 proposals will be processed by the DARPA Contracts Management Office 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.
- **Successful offerors will be expected to begin work no later than 30 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 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 ANYTIME during the 6th month of the Phase I effort. The Fast Track Phase II proposal must be submitted no later than the last business day in the 7th month of the effort. **Technical dialogues with DARPA Program Managers are encouraged to ensure research continuity.** 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 generally, will not exceed $40,000.

To encourage the transition of SBIR research into DoD Systems, DARPA has implemented a Phase II Enhancement policy. Under this policy DARPA will provide a Phase II company with additional Phase II SBIR funding, not to exceed $200K, if a DARPA Program Manager can match the additional SBIR funds with DARPA core-mission funds or the company can match the money with funds from private investors; or at the discretion of the DARPA Program Manager. DARPA will generally provide the additional Phase II funds by modifying the Phase II contract.

DARPA FY2002.1 Phase I SBIR
Checklist

1) Proposal Format

a. Cover Sheet (formerly referred to as Appendices A and B) **MUST** be submitted electronically (identify topic number) ______

b. Identification and Significance of Problem or Opportunity ______

c. Phase I Technical Objectives ______

d. Phase I Work Plan ______

e. Related Work ______

f. Relationship with Future Research and/or Development ______

g. Commercialization Strategy ______

h. Key Personnel, Resumes ______

i. Facilities/Equipment ______

j. Consultants ______

k. Prior, Current, or Pending Support ______

l. Cost Proposal (see Appendix C of this Solicitation). Ensure your cost proposal is signed. ______

m. Company Commercialization Report (formerly referred to as Appendix E) **MUST** be registered electronically and a signed hardcopy submitted with your proposal (register at http://www.dodsbir.net/submission) ______

2) Bindings

a. Staple proposals in upper left-hand corner. ______

b. **DO NOT** use a cover. ______

c. **DO NOT** use special bindings. ______

3) Page Limitation

a. Total for each proposal is 25 pages inclusive of cost proposal and resumes. ______

b. Beyond the 25 page limit do not send appendices, attachments and/or additional references. ______

c. Company Commercialization Report (formerly referred to as Appendix E) **IS NOT** included in the page count. ______

4) Submission Requirement for Each Proposal

a. Original proposal, including signed Cover Sheet (formerly referred to as Appendix A) ______

b. Four photocopies of original proposal, including signed Cover Sheet and Company Commercialization Report (formerly referred to as Appendices A, B and E) ______

INDEX OF DARPA FY2002.1 TOPICS

SUBJECT/WORD INDEX TO THE DARPA FY2002.1 TOPICS

Subject/Keyword Topic Number

FY2002.1 DARPA Topic Descriptions

DARPA SB021-001 TITLE: Continuous Wave Terahertz Source

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Technological advancements in the terahertz (10^{12} Hz) region of the electromagnetic spectrum have been hampered by the lack of cost effective sources of terahertz radiation. Applications in ranging, imaging, and communications are just a few of the areas that would benefit from efficient terahertz sources. The objective of this task is to develop a cost effective device to produce continuous wave, coherent, terahertz radiation.

DESCRIPTION: The optical, infrared, millimeter, and microwave portions of the electromagnetic spectrum have been extensively exploited for communications, radar, imaging, and other military and civilian applications. The ability to utilize practical systems in these portions of the electromagnetic spectrum is a result of the availability of cost effective sources and detectors in each spectral region. While terahertz sources do exist, they tend to be bulky and expensive. To date, the available sources consist of extremely large systems, such as free electron lasers, or use pulsed optical radiation to generate pulses of terahertz radiation. While the pulsed radiation has many applications, there is also a need for continuous wave sources in the terahertz range, particularly coherent sources. Without cost effective sources, the terahertz region of the spectrum will remain an interesting area of research confined to specialized applications. Recently, the field of photonic band engineering has emerged as a possible approach to solving the problem of terahertz sources. A photonic band crystal composed of nonlinear optical materials can provide frequency conversion through parametric processes [1]. This approach has been exploited in the near-infrared region of the spectrum to produce coherent electromagnetic radiation [2]. The goal of this solicitation is to develop a cost effective source of continuous wave, coherent radiation in the terahertz region. While an approach based on photonic band engineering is suggested, other methods will be considered if the device is based on sound scientific principles with supporting documentation.

PHASE I: Clearly demonstrate the feasibility of the proposed approach to generate continuous wave, coherent terahertz radiation. Provide a detailed description of the theory of operation and an in depth discussion of fabrication issues and testing methods.

PHASE II: Building upon the Phase I effort, develop a prototype device. Perform appropriate testing and analysis to demonstrate operation of the device, develop operational concepts and procedures, and provide a pathway for commercial development of devices based on this concept.

PHASE III DUAL USE APPLICATIONS: The resulting prototype device will serve as a basis for development of commercial systems. Applications for terahertz radiation include communications, collision avoidance for airborne and ground based vehicles, atmospheric sensing, medical imaging, ranging, and spectroscopy.

KEYWORDS: Terahertz Devices, Terahertz Sources, Communications, Atmospheric Sensing, Photonic Band Engineering, Medical Imaging, Spectroscopy, Optical Parametric Oscillator.

REFERENCES:

1. M. Centini, et al, Optics Communications, Volume 189, p. 135 (2001).
2. Y. Dumeige, et al, Applied Physics Letters, Volume 78, p. 3021 (2001).

DARPA SB021-002 TITLE: Unique Packaging of Exposed MEMS Sensors

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: To develop novel, low-cost packaging processes and designs for MicroElectroMechanical Systems (MEMS) sensors that require exposure to the environment for operation, such as humidity and adverse chemical sensors for missile health monitoring applications.

DESCRIPTION: With increasing developments in MicroElectroMechanical Systems (MEMS), new sensing techniques and devices are emerging rapidly. However, significant deterrents to military application of many of these devices exist. One area of primary concern exists with environmentally exposed micro sensors, such as humidity sensors and adverse chemical sensors. In order for these devices to accurately measure the parameter at issue, they must be exposed to the environment, producing an inherent reliability risk. Additionally, many packaging schemes, such as cylindrical sidewall protectors, create board-yield risk due to trapped fabrication processing liquids or debris. Furthermore, packaging of these sensors makes them cost prohibitive in many cases. For example, a MEMS humidity sensor die is easily producible for $1 – $3 each, yet a packaged MEMS humidity sensor, ready for printed circuit board (PCB) mounting, costs $100 – $200 each. This is unacceptable. Therefore, a technology barrier in packaging and/or mounting techniques must be breached to make these MEMS sensing devices cost effective and reliable. Due to the broad applicability of MEMS devices to so many various systems, there will not be a one-size-fits-all package or universal form of package. The package itself, since it is also a miniature system, couples into the MEMS system and greatly effects performance. Various package styles and techniques will affect the thermal, electromagnetic interference (EMI), mechanical stress, and reliability characteristics of the sensors in various ways. Therefore, MEMS packaging technologies should be explored, to the extent that a wide variety of techniques exist, and a selection of package styles or techniques can then be used in a particular application. This situation has occurred in the microelectronics arena where a system designer can now get surface-mount technology (SMT), Through-hole, Flip-Chip, standard outline (SO), single small outline (SSO), plastic leadless chip carrier (PLCC), J-Lead, and many other package styles all with different performance characteristics and costs. The designer can then fit those into the application as is seen fit. The problem of MEMS packaging is almost as broad a research area as is development of MEMS devices. Many organizations are currently exploring various aspects of packaging by investigating the use of new materials, new processes, new package designs, and new standards to aid in the packaging of humidity, temperature, and acceleration sensors. However, chemical sensors are an entirely different type of device with very unique packaging requirements. In addition, different sensors for different chemical species may have differing packaging requirements. For micro-optical systems, some packaging techniques used in opto-electronics packaging can possibly be modified for use in MEMS devices. However, these techniques have been developed for the telecomm industry, are not required often, and are still extremely expensive. Batch fabrication, active alignment, and automated placement are all techniques that could reduce packaging costs associated with micro-optical systems. Proposals should address as many exposed sensor types as possible in accordance with the issues above. Award consideration will be based heavily upon the completeness of addressing the named concerns, the innovative nature of the technology proposed, the economical advantages of the device(s) and process(es) proposed, the applicability of the devices to both military and commercial uses, and the performance specifications/expectations of the packaged sensor(s).

PHASE I: Identify specific packaging requirements and techniques for MEMS sensors, addressing particularly those sensors requiring exposure to the environment. Develop a detailed approach and schedule for maturing MEMS packaging technologies. Design packaging concepts and verify MEMS die and package integration feasibility via modeling. Define theoretical limitations of, and any technological barriers to implementation of, your concept (including such parameters as packaging effects on performance, size, reliability, cost, etc.). Quantify the advantages of your approach, and conduct proof-of-principle experiments to verify proposed techniques. All devices must ultimately demonstrate reliability over a temperature range of -57°C to +95°C for a 10-year life.

PHASE II: Illustrate analytical concepts that demonstrate the capability of the proposed technology(ies) and provide robust, low-cost, ultra-reliable MEMS sensing devices for military applications. Validate your Phase I concepts by packaging prototype MEMS sensors for military applications. Teaming with government, industry, or academia foundries as necessary is encouraged. Confirm performance through laboratory testing and quantify performance specifications for the packaged micro-devices.

PHASE III DUAL USE APPLICATIONS: The dual use potential of the product(s) from this effort is phenomenal. Markets extend from numerous automotive, aeronautical and robotic applications to mining and oil-drilling applications to medical and food industry applications. Potential market sales of packaged, small, low-cost conformal environmental and inertial sensing devices are astronomical.

KEYWORDS: MEMS, Sensors, Packaging, Micro-Optics, Materials.

REFERENCES:

1. Department of Defense, "Microelectromechanical Systems: A DoD Dual Use Technology Industrial Assessment," December 1995.

DARPA SB021-003 TITLE: <u>Bistatic Terrain Scattering Model for Microwave SAR Simulation</u>

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop parametric innovative bi-static terrain scattering models to cover L-band through Ku-band scattering at arbitrary polarization. A variety of vegetation types including leaves, stalks, twigs, etc requires new theoretical development as well as new ideas for software implementation and run-time efficiency. Models must support a variety of terrain type and roughness and vegetation cover. Develop a scene simulation that makes use of Digital Terrain Elevation Data (DTED) and Land-Cover/Land-Use databases to simulate bi-static Synthetic Aperture Radar (SAR) maps. Simulation must be capable of being embedded into a SAR system simulation.

DESCRIPTION: Bi-static SAR concepts offer the capability for covert passive operation. Missions include improved battlefield awareness, support for Special Operations, target detection, and precision targeting. The use of large bi-static angles offers significant advantages for enhanced terrain scattering and interferometric height sensing accuracy. A few bi-static terrain scattering models have been developed for a limited terrain, and a limited amount of experimental data has been collected. In addition, comprehensive worldwide databases exist from which realistic terrain slopes, and cover are available. Performance of current and future sensor programs depends critically upon the characteristics of terrain scattering. Sensitivity to local slope, dielectric properties, polarization, resolution, and the degree to which these effects will affect sensor products are of concern. A single innovative and creative simulation capable of modeling a variety of terrain and system parameters, which is flexible and highly automated, is essential to the success of these sensor programs. By federal regulation governing SBIR's, "Rights in technical data, including software, shall remain with the contractor, except that the government shall have the limited right to use such data for government purposes and shall not release such data outside of the government without the permission of the contractor for a period of five years from completion of the project from which the data was generated, unless the data has already been released to the general public. However, at the end of the five-year period, the government shall retain a royalty-free license for government use of any technical data delivered under the contract."

PHASE I: Develop and implement in a widely available and transportable source code, innovative and creative models sufficient to describe realistic bare earth and vegetated terrain over the range of sensor parameters described above. Select, collect and display DTED and land cover databases to be used in a simulation to be developed in Phase II.

PHASE II: Develop a simulation of bi-static SAR making use of the innovative and creative clutter models and interfaces with existing database developed in Phase I.

PHASE III DUAL USE APPLICATIONS: SAR finds application in military surveillance and commercial remote sensing. The use of scattering geometries other than backscatter allows passive operation, which is important to the military, and potentially offers a more general remote sensing capability. In either case, realistic characterizations of terrain scattering are critical to both the design of these systems and utility of the products that they generate.

KEYWORDS: Bi-static, SAR, Resolution, Imagery, Clutter, Remote Sensing.

REFERENCES:
1. H. T. Ewe and H. T. Chuah, "Electromagnetic Scattering from An Electrically Dense Vegetation Medium," IEEE Transactions on Geoscience and Remote Sensing, Vol. 38, No. 5, September, 2000.
2. R. J. Papa, et. al, "The Variation of Bistatic Rough Surface Scattering Cross Section for a Physical Optics Model," IEEE Transactions on Antennas and Propagation, Vol. AP-34, No. 10, October, 1986.
3. M. Y. Xia, et. al, "Wavelet-Based Simulations of Electromagnetic Scattering from Large-Scale Two-Dimensional Perfectly Conducting Random Rough Surfaces," IEEE Transactions on Geoscience and Remote Sensing, Vol. 39, No. 4, April, 2001.

DARPA SB021-004 TITLE: Densely Multiplexed Photonic mm-wave Radio Modulator and Demodulator

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop a photonic mm-wave radio modulator and demodulator to support high frequency broadband wireless networks.

DESCRIPTION: In the future, an ad hoc mm-wave wireless communications system will network a large number of battlefield elements. The ability to support large numbers of nodes requires maximally efficient use of the available radio frequency (RF) spectrum. Some promising schemes for efficient spectral usage depend on low phase noise carrier generation with wideband modulation bandwidth. For example, an extension of cell phone code division multiple access (CDMA) encoding with high M-ary phase shift keying would support large numbers of nodes in a cell. Emerging photonic low phase noise carrier generation schemes and electro-optic modulators [refs] are good candidates for such systems.

PHASE I: Design a photonic mm-wave signal modulator and demodulator operating at 38 GHz and perform a proof-of-principle experiment to demonstrate efficient spectral usage.

PHASE II: Design, fabricate and demonstrate a densely multiplexed mm-wave photonic modulator/demodulator. Use the demonstration and analysis to determine the limits of channelizing using this approach.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used to offer a wireless last mile Internet connection product to businesses in urban areas where fiber infrastructure is expensive. It may be used to expand the number of channels offered by Local Multipoint Distribution Service (LMDS) at 28, 38 and 40 GHz bands.

KEYWORDS: MM-Wave, Wireless Communications, Photonic, Bandwidth, RF, Radio Frequency.

REFERENCES:
1. L. Noel, D. Wake, D. G. Moodie, D. D. Marcenac, L. D. Westbrook, and D. Nesser, "Novel Techniques for High Capacity 60 GHz Fiber Radio Transmission Systems," IEEE Transactions on Microwave Theory and Techniques, v. 45, no. 8, p. 1416, 1997.

DARPA SB021-005 TITLE: <u>Mathematical Methods for Video Registration in Autonomous Navigation Applications</u>

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop robust technology for registration of video imagery with database imagery that is based on rigorous mathematical foundations and is applicable to autonomous or semi-autonomous vehicle navigation.

DESCRIPTION: Automation of navigation functions, including such sophisticated tasks as landing of unmanned air vehicles (UAVs), avoidance of terrain, and routing of cruise missiles to distant targets without reliance on Global Positioning System (GPS) data, is increasingly important in numerous Defense applications. In situations where a database of reference imagery is available, reliable and computationally efficient means for registration of real-time video sensor data with reference imagery can provide the foundation for autonomous navigation. This effort seeks to develop and demonstrate mathematically sound methodologies for image registration that are suitable for computationally efficient implementation and are robust with respect to rotation and perspective, partial occlusion, unknown and incomplete scene overlap, temporally-based variations, and other inconsistencies between acquired and archived images and image sequences. Several approaches for registration of images, including both direct correlation and feature-based methods, have been described in the research literature (see [1] for a survey) and some attention has been given to various robustness issues [2,3]. Among those methods that have solid mathematical foundations, little attention has been given to issues of computational efficiency, which are crucial for real-time applications such as automated aircraft landing [4] and are expected to hinge on innovative mathematical approaches to data dimensionality reduction.

PHASE I: Define a mathematically sound, robust, and computationally efficient approach for registration of images with an imagery.

PHASE II: Implement a prototype system capable of supporting significant proof-of-concept demonstrations involving actual database imagery and real-time or simulated real-time imperfect image sensor data.

PHASE III DUAL USE APPLICATIONS: The methodology, specific algorithms, and software developed will have applications to autonomous or semi-autonomous navigation of air, ground, and undersea vehicles in a wide variety of Defense and other settings. In the Defense context, potential applications include autonomous navigation of cruise missiles and other UAVs, navigation of Unmanned Undersea Vehicles (UUVs), and automated landing systems for UAVs. Numerous possible commercial products based on the algorithms include robotic systems for surveying and search, computer tools for image and video data mining for criminology (e.g., matching security camera video to mugshot databases), and automated security patrolling equipment.

KEYWORDS: Sensors, Video, Registration, Navigation.

REFERENCES:
1. Brown, L.G., “A survey of image registration techniques,” ACM Computing Surveys, vol. 24(4), pp. 325--376, 1992.
2. Monasse, P., “Contrast invariant image registration,” Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing, pp. 3221—3224, 1999.
3. De Castro, E. and C. Morandi, “Registration of translated and rotated images using finite Fourier transforms,” IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 5(2), pp. 700—703, 1983.
4. Dickmans, E.D. and F.R. Schell, “Autonomous landing of airplanes by machine vision,” Proceedings of the IEEE Workshop on Applications of Computer Vision, pp. 172—179, 1992.

DARPA SB021-006 TITLE: <u>Novel Concepts for Soldier-Centric Technology in Non-Traditional Combat Casualty Care</u>

KEY TECHNOLOGY AREA: Biomedical

OBJECTIVE: To develop novel medical technology that allows the individual warfighter to overcome acute battlefield injuries in an austere and isolated environment.

DESCRIPTION: Statistics show that relatively minor injuries are responsible for nearly two-thirds of combat casualties in the battlefield. Nonetheless, even these minor injuries often lead to evacuation, which compromises the unit and can lead to mission failure. Hemorrhage accounts for forty percent of deaths in the battlefield. Technology that allows the warfighter to stabilize his injury and overcome his immediate need for classical medical care will result in a reduction in morbidity and mortality in the battlefield, and an increase in soldier persistence. These concepts must focus on automated diagnostic and therapeutic capabilities to allow a non-medic warfighter to overcome operational combat hazards from conventional munitions, laser weapons, chemical weapons and radiation. Ultimately these technologies must be light enough to carry in a backpack, or incorporated into the soldier's Battle Dress Uniform (BDU).

PHASE I: Phase I research will investigate novel technologies that could allow the soldier to have the capability for immediate diagnosis, treatment, pain control, stabilization of injury and accelerated tissue repair.

PHASE II: Specific technologies will need to be augmented into existing soldier-borne platforms using non-invasive devices. An example for hemorrhage control may be flexible garment-based materials to transform into rigid "exo-splint" like devices to stabilize a long bone or cervical neck fracture. Tourniquets are difficult to apply as a "self-aid" device, novel concepts may be considered as an automated "G-suit" (tourniquet-like device) that would provide proximal external compression to specific areas of bleeding for hemorrhage control. Operational combat hazards of interest include self-diagnosis for pneumothorax, heat/cold stress, toxin exposure, internal bleeding and musculoskeletal injuries. Acceleration of tissue repair in a battlefield environment using electromagnetic fields such as near infrared, millimeter waves and radio frequency would enable a functioning soldier in a combat environment.

PHASE III DUAL USE APPLICATIONS: Commercial applications of this wide spectrum of technology could include skin care, trauma management, and chronic pain therapy in hospitals and outpatient clinics. This self-aid technology would transition to use by forest firefighters, outdoor recreational adventurers and others in remote locations where medical aid is not readily available.

KEYWORDS: Electromagnetic Therapy, Tourniquets, Splints, Acceleration of Healing, Stabilization of Injury.

REFERENCES:

1. Textbook of Military Medicine Anesthesia and Perioperative Care of the Combat Casualty. 1995. *Office of the Surgeon General, Department of the Army, United States of America.*

DARPA SB021-007 TITLE: Quality Water Lubrication of Special Triboceramics, Alloys and Self-Lubricating Composites

KEY TECHNOLOGY AREA: Materials / Processes

OBJECTIVE: The objective of this study is to lay the groundwork of tribological fundamentals for advanced water-lubricated steam engines intended for both mesoscale and macroscale use. The main goal here is to determine the load/speed/temperature (to 100 deg. C) dependent friction and wear of (a) triboceramics, which in the presence of water form lubricative surface substances (e.g., aluminum hydroxide on the top of alumina hydrated silica on the top of silicon nitride and silicon carbide), (b) metal alloys resistant to gross water-induced corrosion, but which in the presence of water form benign corrosion products (such as hydrated oxides-hydroxides) which could be construed as lubricative at low to moderate Hertzian stresses, and (c) other self-lubricating materials (e.g., certain forms of carbons, graphites and polymeric composites, which act as structural tribomaterials in the presence of water.

DESCRIPTION: If sufficiently high power densities can be achieved by the judicious use of design and selection of materials, the use of advanced steam engines, where both the working fluid (steam) and the lubricant (water without or with special water-compatible additives) are water, is highly desirable both for military and civilian applications. The ultra-quiet and ecologically advantageous nature of steam engines could allow the design and development of motors. The contractor must have the appropriate environmental tribotest apparatus to approximate the realistic loads, speeds and temperatures one would normally find in advanced steam engines during tribometry of the various likely commercially available and specially formulated and commercially available materials. The materials must be paired in realistic tribosystems one could expect to find in piston or turbine-operated engine designs, first in a pure water and steam, and later in additive-containing liquid and vapor phase environment. The results must be presented in wear maps describing the performance of the various tribomaterials in terms of load/speed/temperature-dependent friction values and wear rates as m^3/Nm of sliding, so designers can create likely materials and configurational variations necessary for the various likely Hertzian contact configurations of steam engine moving mechanical assembly components.

PHASE I: Identify those ceramics, metallic alloys and self-lubricating composites, which lend themselves best for the defined load/speed/temperature/sliding mode (unidirectional or oscillatory) and water/steam environment of the most appropriate tribosystem combinations. Select at least one point-contact and one area-contact environmental tribometer, by which the Hertzian stress-, sliding velocity-, and thermal-atmospheric environment-dependent tribological properties of these materials can be determined. Select at least two different ceramics, two metallic alloys and two self-lubricating composites to preliminarily determine these parameters to the limiting PV (pressure-velocity) and thermal-environment limit characteristic to these materials, using pure water and steam atmosphere environment at or somewhat higher than 100 deg. C. Rationalize the selection of the most likely tribomaterials and justify the down select of the final candidates for friction and wear testing by supplying key review articles, technical papers or other pertinent references.

PHASE II: Based on the results of Phase I, map the entire likely triboenvironmental regime of each of the six model materials using the test apparatus and pure water/steam environment employed in Phase I to establish a baseline for a wider screening study using other likely, commercially available and specially formulated tribomaterials analogous to the model ceramics, alloys and self-lubricating materials but with vastly improved properties. Prediction of the improved properties must be made by known friction, wear and lubrication principles combined with the knowledge of the behavior of structural materials in a high temperature water and steam environment. Search the literature for the best water-compatible additives, which might be able to reduce the tribochemical wear of the six model materials, and perform friction and wear testing in water-additive and steam-additive environments to demonstrate the possible reduction in friction and wear rate as a function of additive chemistry and content.

PHASE III DUAL USE APPLICATIONS: The use of advanced steam engines, where both the working fluid (steam) and the lubricant (water without or with special water-compatible additives) are water, is highly desirable both for military and civilian applications. This would include military and commercial generators and power plants as well as both military and commercial vehicles.

KEYWORDS: Water-Lubrication, Tribology.

REFERENCES:
1. "Sliding Friction and Wear of Ceramics in Neutral, Acid, and Basic Aqueous Solutions," B. Loffelbein, M. Woydt and K. H. Habig, Wear, (1993), 162-164, 220-228.
2. "Tribochemical Mechanism of Alumina with Water," R. S. Gates, S. M. Hsu, E. E. Klaus, Tribology Transactions, vol. 32, (1989), 3, 357-363.
3. "Tribochemistry of Silicon-Based Ceramics under Aqueous Solution," K. Mizuhara, S. M. Hsu, Eurotrib. 93, vol. 3, (1993), 52-57.
4. "Silicon Nitride Boundary Lubrication: Lubrication Mechanism of Alcohols," R. S. Gates, S. M. Hsu, Tribology Transactions, vol. 38, (1995), 3, 648-653.
5. "Friction and Wear of Silicon Nitride and Silicon Carbide in Water: Hydrodynamic Lubrication at Low Sliding Speed Obtained by Tribochemical Wear," H. Tomizawa, T. E. Fischer, ASLE Transactions, vol. 30 (1987), 1, 41-46.
6. "The Transition of Wear Mode During the Running-In Process of Silicon Nitride Sliding in Water," Wear, vol. 205 (1997), 55-63.
7. "Water Lubricated Sliding Wear of Ceramics Si_3N_4 and Al_2O_3 against Gray Cast Iron," Y. M. Gao, L. Fang, L. Zhou, J. T. Su, Mechanical Engineer, Vol. 32 (1996), 2, 8-12.

DARPA SB021-008 TITLE: Detecting Misleading Information

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop and demonstrate intelligent agent software capable of detecting (intentionally) misleading information from potential threat groups in open sources.

DESCRIPTION: Techniques for intelligence gathering from open sources recognize that open source information is 100% consistent, accurate and reliable; however, they do not adequately address the possibility that it may be intentionally inaccurate. Inaccurate information might be posted regarding transactions, payments, contacts, members, roles, employment/affiliation history, education, background, front companies, business partners, business volume, business types, contracts, etc. This inaccurate information is designed not only to hide the true capabilities and intentions of a terrorist group, but also to make it appear legitimate. What is needed is intelligent agent software that is capable of reviewing web sites and identifying implausible or inconsistent information, such as companies who claim contracts incommensurate with their business history or size, companies who make unverifiable claims, persons who have "missing periods" in their background, persons whose positions are inconsistent with their experience, transactions inconsistent with the type, location, or nature of a business, etc. Such agents would be specific to particular domains of interest and likely would rely on a large amount of domain-specific knowledge. They would have to avoid high false-alarm rates. A set of such agents, specific to different domains, would work together to achieve high true-positives while avoiding high false alarms. The results of work performed under this SBIR would have to demonstrate the ability to find useful leads related to actual potential threats. It should allow for the incorporation of specific threat information so the agents could find misleading information that may indicate activities by these threat organizations or people. Research advances are needed in reasoning about adversaries, use of background knowledge, temporal reasoning, and common-sense reasoning.

PHASE I: Determine feasibility of distinguishing misinformation from accurate or unreliable information by conducting experiments on selected corpus of data from internet sites and other open sources. Identify characteristics of data that affect performance goals.

PHASE II: Implement prototype software to demonstrate the ability to detect misinformation in a real-time internet-based environment, using selected sites (e.g., news providers, organizational sites, etc.). Evaluate by constructing receiver operating characteristic (ROC) curve for precision-recall tradeoff.

PHASE III DUAL USE APPLICATIONS: Techniques for detecting intentionally misleading information are useful not only for military forces but also for regulatory and commercial organizations. HCFA (Health Care Financing Administration) could use these techniques for Medicare fraud detection. The SEC (Securities & Exchange Commission) could use these techniques for detection of stock frauds, the FTC (Federal Trade Commission) for detection of anti-competitive behavior. Commercial organizations could use these techniques for business intelligence gathering about their competitors' plans and capabilities. Personnel departments could use these techniques to verify claims on resumes. Insurance companies could use them for investigations of fraudulent claims.

KEYWORDS: Information Warfare, Fraud Detection, Activity Monitoring, Pattern Detection, Adversarial Reasoning, Common-Sense Reasoning, Plausible Reasoning, Evidential Reasoning, Information Operations.

REFERENCES:

1. AI Approaches to Fraud Detection and Risk Management, Technical Report WS-97-09, AAAI Press, 1997
2. http://www.kdnuggets.com/solutions/fraud-detection.html

DARPA SB021-009 TITLE: Modeling Asymmetric Economic Threats to Critical DoD Technology Sectors

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop an effective and valid family of predictive models that will effectively project asymmetric threat factors that could individually or in aggregate adversely affect economic stability of critical DoD technology sectors. The model shall be capable of projecting trends and interactive effects of projected trends, as well as presenting prevention/intervention strategies.

DESCRIPTION: In 1997, the FBI Director Louis Freeh testified to Congress that foreign companies from 23 nations were involved in the illicit acquisition of US trade secrets and that 12 of those countries have aggressively "targeted US proprietary economic information and critical technologies." A recent American Society for Industrial Security (ASIS) report estimated that the number of cases of industrial espionage directed at U.S. technology industries have grown 260% since 1985 and is currently estimated at over $410 billion a year. The primary targets include, but are not limited to, biotechnology; aerospace; telecommunications, including the technology to build the National Information Infrastructure; computer software and hardware; advanced transportation and engine technology; advanced materials and coatings, including "stealth" technologies; energy research; defense and armaments technology; manufacturing processes; and semiconductors. These industries are of strategic interest to the United States on three levels: 1) they produce classified products for DoD; 2) they produce dual-use technology used in both the public and private sectors; and 3) they are responsible for R&D and creation of leading-edge technologies critical to maintaining U.S. technological dominance. Losses at any of these levels could affect U.S. international competitiveness and security. To adequately identify and counter emerging external economic threats to critical DoD technology sectors, it is necessary to develop new models capable of projecting global as well as national technology sector trends, the corresponding external factors contributing to such trends, and the variables that can directly or indirectly be manipulated to adversely affect our national security. To date, asymmetric warfare modeling attempts have not focused on threats to our technological vulnerability through economic stability. Predictive technologies based on organizational behavior, in general, are still in the development stage. To meet the objectives of this SBIR, research may include existing models or combinations of models, as well as newly developed models, as applied to this new focus.

PHASE I: Conceptualize and describe valid economy predictions and intervention models that can identify variables that can affect the critical DoD technology sectors and can be manipulated within an asymmetric framework. The model will emphasize how such identified variables may result in an increased asymmetric threat to stability and how prevention and intervention may be used to reduce or eliminate such threat.

PHASE II: Develop and apply an implementation of the proposed model. The model will be based on relevant historical data and will be capable of identifying key variables that have adverse effects on national economic stability. Second, the model will be capable of projecting vulnerabilities from an asymmetric warfare perspective, as well as generating prevention and intervention scenarios. The implementation must include complete documentation to allow for direct replication of methods and results across a variety of threats to economic stability.

PHASE III DUAL USE APPLICATIONS: The development of an effective economic model will allow for more accurate anticipation of asymmetric threats to national economic stability. The generation of probable prevention and intervention scenarios would be useful in the event that asymmetric threats are realized. A valid model will present multiple opportunities for commercial applications such as decision aids and training tools for investment and market sector analysis for private industry. Such applications would provide means by which countermeasures to identified threats could be developed and implemented to decrease the probability of asymmetric threat. The model and prevention/intervention scenario generation would have utility from both corporate and government proactive perspectives.

KEYWORDS: Economic Stability, Asymmetric Warfare, Threat Assessment.

DARPA SB021-010 TITLE: Modeling Organizational Behavior within Operations Other than War

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop a family of adaptive organizational models representing the key organizational components (e.g., rogue nations, civilian populations, non-governmental organizations, coalition forces) to support mission planning and rehearsal for Operations Other Than War (OOTW).

DESCRIPTION: With the fall of Soviet communism in 1989, the bipolar world that very much defined our national defense strategy disappeared. Other than the Gulf War, our military emphasis has been dominated by OOTW actions such as peacekeeping, peace enforcement, nation building, disaster relief, etc. While today's physics-based maneuver and attrition models proved valuable in preparation for Desert Storm, their inability to address the behavioral component of the myriad of OOTW participants were noticeably absent during preparation for Bosnia and Kosovo. Research advances in the area of organizational and behavioral modeling offer potential enhancements to the mission planning and rehearsal capability for OOTW. However, there still remain some significant challenges to modeling the robust characteristics necessary to adequately represent and provide an OOTW planning and rehearsal capability. Technology shortcomings include modeling non-doctrinal organizations, organizational dynamics, and behavior moderators that stimulate organizations to act and then to act in a specific way. In an effort to meet the objective of this SBIR, research may draw upon existing models, architectures, and techniques or create new ones. However, the approach should yield a significantly enhanced mission planning and rehearsal capability in the following areas: behavior models tailorable to new populations and cultures; behavior models tailorable to new rules of interactions, and automated development of recommended courses of action with links to key decision parameters.

PHASE I: Create and describe a conceptual model of key organizational components based on behavioral and scientific modeling strategies and methodologies, including a clear description of the metrics to be used to demonstrate the reliability and validity of the proposed model. The description shall indicate how the model will be generalizable across organizations. Furthermore, the description shall indicate how the model test bed may be applied to specific situations and events from regional and cultural perspectives.

PHASE II: Create an implementation of the models to embody complete functionality of the components being demonstrated and validated; provide complete documentation of test cases and validation results.

PHASE III Dual Use Applications: The development of organizational modeling algorithms and technologies will have a very strong commercial potential with applications such as municipal planning, law enforcement (security agencies such as FBI, DEA, Secret Service), emergency management response (FEMA), international corporations, and non-government organizations (Red Cross).

KEYWORDS: Operations Other Than War, OOTW, Cognitive Modeling, Behavior Modeling, Organizational Modeling, Mission Planning, Mission Rehearsal.

DARPA SB021-011 TITLE: Multi-Modal Control for Automatic Vehicle Management Systems

KEY TECHNOLOGY AREAS: Air Platforms, Information Systems Technology, Ground and Sea Vehicles, Human Systems

OBJECTIVE: Devise provably safe and certifiable control technologies for automatic mode transitions involving manual and automatic controls for moving vehicles, on land, sea, or air.

DESCRIPTION: Advanced vehicle management systems (VMS) are now capable of fully autonomous control of automated highway vehicles, unmanned ground vehicles (UGVs), surface craft, and manned and unmanned aircraft. However, many of these vehicles also operate, at various times or in different conditions, either manually or in various degrees of autonomy. Such conditions include fault recovery, takeoff and landing, high traffic, or in extreme and emergency situations. Manual operation may take the form of on-board operation (i.e., optionally-piloted vehicles), or through remote control, though the emphasis here is on optionally piloted vehicles as opposed to teleoperation. Technology is needed to manage the transition between automatic and manual control, switching between different levels of autonomy, and the underlying stability and control mechanisms that permit safe and reliable operation in mixed manned/unmanned environments. Such technologies include integrated autonomous/manual hybrid control systems, innovative situation awareness to include intra- and extravehicular states, multi-vehicle sensing and information technology, tools for intelligent autonomous-mode fault detection and mitigation, connectivity to mission management systems, multi-mode instrumentation, and control inputs. Common to all these areas will be the need for high-confidence, certifiable control software.

PHASE I: Identify provably stable transition control technologies for manual/autonomous and variably autonomous modes of operation. Determine implications for user interface design; control input devices, and information transfer. Demonstrate correctness and safety in a wide range of simulated hazard, mode transition, and mission phase transitions.

PHASE II: Implement and demonstrate a variably autonomous vehicle controller for an optionally piloted air or land vehicle. Prove stability and correctness bounds in a variety of failure modes and operator intervention scenarios. Consider psychophysical effects such as driver/rider comfort and performance limitations in automated passenger vehicles. Address certifiability of the resulting design.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR may be used in automated vehicles, personal transportation, civil and military UAVs and UGVs, and for manned vehicles that are operated with full or partial manual control for testing and evaluation purposes.

KEYWORDS: Autonomy, Automated Vehicles, Personal Transportation, Hybrid Control Systems, Flight Control Systems, Vehicle Management Systems.

REFERENCES:

1. Ken Funk, Beth Lyall, and Vic Riley, "Perceived Human Factors Problems of Flightdeck Automation," http://flightdeck.ie.orst.edu/FDAI/Phase1/phase1.html, and bibliography therein.
Mica Endsley, "Situation Awareness, Automation, and Free Flight," http://atm-seminar-97.eurocontrol.fr/endsley.htm.
2. Thomas b. Sheridan, *Telerobotics, Automation, and Human Supervisory Control*, MIT Press, 1992.
3. John Lygeros, Datta N. Godbole and Shankar S. Sastry, "Verified Hybrid Controllers for Automated Vehicles," *IEEE Transactions on Automatic Control*, vol. 43, no. 4, pp. 522-539, 1998.
4. John Lygeros, Claire Tomlin, and Shankar Sastry, "Controllers for Reachability Specifications for Hybrid Systems," *Automatica*, Volume 35, Number 3, March 1999.

DARPA SB021-012 TITLE: Tools for Design and Validation of Quantum Algorithms and Protocols

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop software tools to aid in the design and validation of algorithms and protocols for the use and transmission of quantum information.

DESCRIPTION: Quantum information systems for computation and communication are of increasing interest in both military and commercial applications. Design of algorithms and protocols for quantum systems presents new challenges, including: novel fundamental operators; the probabilistic nature of many quantum algorithms and protocols; the diversity of possible implementations of quantum information; and inherent faults such as decoherence that must be tolerated. In addition to new algorithms and protocols, variants of existing ones are needed, both for expanded applicability and for implementation reasons. For example, the quantum Fourier transform that is at the heart of Shor's factoring algorithm [1] has also been applied to finding the order of a permutation [2]. As another example, the BB84 protocol [3] for key distribution must be augmented for implementation by adding intrusion detection, privacy amplification, and other modifications. Finally, depending on the implementation, any algorithm or protocol will need to be modified for control of implementation-dependent errors. Software tools are needed, both to meet the design and validation challenges for new quantum algorithms and protocols, and to ease the construction and validation of new variants of existing algorithms and protocols. Tools may include simulators, visualization tools, languages and translators, timing estimators, and other software.

PHASE I: By the end of Phase I, the expected accomplishment is an architecture for a tool or tool suite, together with evidence that the tools could be applied to a non-trivial quantum algorithm or protocol such as Shor's factoring algorithm. The tools should aid in the construction of a variant of the algorithm, or in understanding the correctness, performance, or other properties of the algorithm.

PHASE II: By the end of Phase II, use of prototype tools should be demonstrated in designing or validating a new quantum algorithm, protocol, or variant.

PHASE III DUAL USE APPLICATIONS: Quantum information systems have the potential for greatly improved performance in areas such as information security and the solution of computationally hard problems. Military and commercial applications are very similar; they include secure communication, signal and image processing, and solution of logistical problems. The tools developed under this program will aid in modifying the underlying algorithms for specific applications, and in validating their properties in those applications.

KEYWORDS: Quantum Information, Quantum Computing, Algorithms, Protocols, Simulation.

REFERENCES:

1. Shor algorithm: http://www.theory.caltech.edu/people/preskill/ph229/notes/chap6.ps.
2. Order of a permutation: http://xxx.lanl.gov/ps/quant-ph/0007017 .
3. BB84: http://xxx.lanl.gov/abs/quant-ph/9811056 .

DARPA SB021-013 TITLE: Reading Signs in Context to Support Perception–Based Autonomous Navigation

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop software algorithms to employ a robotic vehicle's sensor suite to detect, localize, track, and read any textual or graphic signboards in the robot's environment. Integrate these sign reading algorithms into a representational and reasoning infrastructure that can reason about the sign and also its environmental context in order to support the selection of appropriate autonomous navigation behaviors.

DESCRIPTION: Human beings are able to navigate confidently in highly complex environments because of their robust perceptual capabilities, which allow them to recognize specific places and to reason about relationships between them. This capability is enhanced, in both outdoor and indoor environments, through the use of signboards presenting text and/or graphical information. When effectively deployed, signboards provide unambiguous information that humans rely on to know where we are and how to get to where we want to go. Signs are used to provide explicit location and direction references (street names and room numbers), behavior instructions (stop signs), and warnings (safety notices). Providing a robot with the ability to read and understand the signs that it encounters in its environment will greatly enhance the robustness of its autonomous navigational capabilities. Signboards, by virtue of the fact that they are intended to be noticed and understood, possess canonical structural features (placement, size, shape, color, and text and/or graphical design) that facilitate the task of "parsing" them from the robot's sensory scan of its environment. Once recognized, signs can serve as highly reliable navigational landmarks, in addition to providing their semantic content. Automated recognition of license plates is now used for law enforcement, and recognition of traffic signs has also been pursued, most notably in Europe and Japan, and mostly based on template matching. This new effort is intended to provide broader-based tools that can move beyond these specific sign types to also deal with signs in indoor environments and with the various other types of signs (e.g., commercial) that humans employ.

PHASE I: Design and implement initial software algorithms to detect, localize, track, and read any textual or graphic signboards in the robot's environment. Characterize the sensor performance (e.g., resolution, speed, range, lighting) required by the sign reading algorithms. Characterize performance levels as a function of relative orientation and distance. Develop a conceptual design for representational and reasoning infrastructure elements to determine whether a sign is situated appropriately in its environment, to capture its semantic content, and to validate its applicability to the robot's navigation task. The output of the sign reader must provide a well-defined perceptual-level input to autonomous planning resources. Provide an initial demonstration to validate the approach.

PHASE II: Augment and refine the sign reading algorithms. Implement the representational and reasoning infrastructure, and develop and populate a world knowledge base about signboards including how they are situated and what they "mean." This will require the perception (and representation) of other environmental features that create the environmental context in which the signs are situated. Demonstrate the system in widely varying environmental conditions (including real roadway traffic) and experimentally validate the performance level achieved.

PHASE III DUAL USE APPLICATIONS: This technology would be a valuable complement to GPS-based navigation systems, providing superior positional resolution and working in the absence of GPS satellite coverage. Road sign perception will enrich dynamic environmental maps with positions acquired by this system and subsequently assist with the precision of current vehicle position information. This vision-based system could be incorporated into intelligent vehicles without requiring new traffic infrastructure devices and could be adapted to operate in different countries. Autonomous robotic systems used for search and rescue, logistics and motor pools, and construction would benefit from this perception-based decision making capability. It is also relevant to manned vehicles, in the context of Intelligent Transportation Systems and Intelligent Vehicles for improved road safety.

KEYWORDS: Perception, Vision-Based Decision Making, Traffic and Road Sign Recognition, Robots, Navigation, Autonomous Behaviors.

REFERENCES:
1. Road Sign Recognition Survey, http://euler.fd.cvut.cz/research/rs2/files/skoda-rs-survey.html
2. Huiping Li, David Doermann, and Omid Kia. "Automatic text detection and tracking in digital videos." *IEEE Transactions on Image Processing*, January 2000.
3. H. Sandoval, T. Hattori, S. Kitagawa, Y. Chigusa. "Angle-dependent edge detection for traffic signs recognition." *Intelligent Vehicles Symposium, 2000. IV 2000. Proceedings of the IEEE*.
4. E.D. Dickmanns, "EMS-Vision" multiple papers in the *Intelligent Vehicles Symposium, 2000. IV 2000. Proceedings of the IEEE*.
5. L. Priese, J. Klieber, R. Lakmann, V. Rehrmann, R. Schian, Image Recognition Laboratory, University of Koblenz-Landau, "New Results on Traffic Sign Recognition." Grant of Daimler-Benz AG within the European PROMETHEUS Project.
6. M.M. Zadeh, T. Kasvand, C.Y. Suen. "Localization and recognition of traffic signs for automated vehicle control systems." *Submitted to SPIE's Intelligent System and Automated Manufacturing*, 1997.
7. G. Piccioli, E. De Micheli, P. Parodi, M. Campani, "A robust method for road sign detection and recognition." *Image and Vision Computing*. 1996.

DARPA SB021-014 TITLE: ElectronicTextiles

KEY TECHNOLOGY AREA**:** Sensors, Electronics and Battlespace Environment

OBJECTIVE: To develop cost-effective mechanisms to interconnect devices to electrically conductive fibers woven into textile fabrics and to form a functional, large-area, flexible, conformable circuit.

DESCRIPTION: Fabrics (textiles) are formed as the result of weaving, knitting, or braiding individual fibers to provide a large-area, flexible product that can be used for a wide variety of purposes (clothing, sheets, wall coverings, rugs, tarps, etc.). The 2-D weaving process involves the overlapping of fibers and produces regular patterns typical of those in an x-y grid. Electrically conducting fibers that incorporate an insulating layer can be fabricated and used as the feedstock for the textile process. The manufacturing tools, processes, and materials employed by the textile industry offer an infrastructure upon which electronic circuits can be fabricated. This effort focuses upon the development of functional but simple circuits on fabrics not greater than one square foot in area. The emphasis is not upon high-performance (high-speed) but upon the feasibility of implementing electronic circuitry on fabrics and exploiting the advantages of textile manufacturing to achieve large-area, flexible, conformable circuitry.

PHASE I: The focus of Phase I will be to create a circuit design that is compatible with textile manufacturing processes and materials. The objective of this phase is to examine alternative methods of attaching electronic components to the fabric and methods to electrically interconnect those components into a functional circuit. Relatively simple circuits such as a memory module or small acoustic array are acceptable. The Phase I deliverable will be a circuit design along with a technical description of attachment/interconnection schemes and a plan describing how the circuit will be fabricated and tested.

PHASE II: The focus of Phase II will be to fabricate a functional circuit based upon the design completed in Phase I. The circuit will be tested in accordance with the Phase I test plan to determine electrical and mechanical integrity and circuit performance.

PHASE III DUAL USE APPLICATIONS: Candidate applications for electronic textiles lie in the domain where large area, flexibility, and conformability are of greater importance than high-speed performance or packaging density. Applications of this technology are in smart clothes, active surfaces (automobiles, airplanes boats, etc.), intelligent living spaces, medical (physiological) monitoring, etc.

KEYWORDS: Electronic Components, Packaging, Textiles, Fibers, Fabric.

DARPA SB021-015 TITLE: Three Dimensional Micro-Fluidics

KEY TECHNOLOGY AREA: Biomedical

OBJECTIVE: Develop integrated, complex micro fluidic flow devices that advance the rapid, multiplexed sample processing of blood or environmental samples and/or identification of biological pathogens by extending the fluidic channels into a third dimension.

DESCRIPTION: Research and development of innovative solutions towards the fabrication of highly integrated micro fluidic devices on smaller footprints that are capable of very large-scale integration (VLSI) with micro fluidic, optoelectronic, electronic components on a chip-scale. These efforts apply current micro fluidic technologies; many of which are under development in the current Biofluidic Chips (BioFlips) Program (www.darpa.mil, Microsystems Technology Technical Office, R&D areas), and advance multiplexed sample processing and sample identification functions through three dimensional micro fluidics utilizing shortened fluidic pathways. The rapid sorting of cells, bacteria, viruses and/or molecules and/or their detection at the molecular level is strongly encouraged. On the fabrication side, platforms (such as those presented by soft lithographic techniques) for low cost devices for the homogeneous or heterogeneous integration of micro fluidic components that may be readily assembled into systems capable of various biological sample-processing functions are sought. Also strongly encouraged is the development of reusable, reconfigurable micro fluidic devices. Additional efforts in device technology include the advancement of methods for multiplexed signal amplification, in-channel direct detection, integrated, compact addressable optical manipulation or detection techniques, schemes for assembling biological processing and detection components through integrated micro fluidic connections, novel micro-pumps/valves and schemes for multiplexing arrays of pumps/valves.

PHASE I: Develop proof of concept design and comparison with state-of-the-art technologies.

PHASE II: Development of a compact, integrated, three-dimensional micro fluidic device capable of demonstrating rapid sample preparation, cell sorting and/or highly sensitive assays.

PHASE III DUAL USE APPLICATIONS: Micro fluidic technologies developed under this topic will be the basis for embedded chips on soldiers to monitor physiological signatures for early detection of bio-warfare agent exposure, triage of bio-events and vital signs monitoring. In addition, such chips may also be utilized in biological sample processing for water quality, air monitoring, on-site testing of blood supply/donor and rapid identification of bio-warfare agents. Commercial applications are most relevant in cell screening, drug discovery, gene expression and diagnostics.

KEYWORDS: Micro Fluidics, BioMEMS, Sample Preparation, Lab-on-a-Chip.

REFERENCES:
1. J. R. Anderson, et. al, vol. 72, Anal. Chem. (2000) 3158-3164.
2. M. A. Unger, et. al, vol. 288, Science (2000) pp. 113-116.

DARPA SB021-016 TITLE: Design Tools for Integrated 3-Dimensional Electronic Circuits

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Development and demonstration of Computer Aided Design (CAD) tools for integrated 3-dimensional (3-D) electronic circuits.

DESCRIPTION: Three dimensional integration offers the potential to significantly improve circuit performance by reducing interconnect lengths and delays that are becoming critical bottlenecks as device sizes continue to shrink and integration densities and chip areas continue to increase. Three-dimensional circuits also offer the promise of integrating disparate technologies within a single block, i.e., memory and logic circuits, radio frequency (RF) and mixed signal components, optoelectronic devices, etc. Although 3-D integration has been the subject of several research efforts, significant challenges associated with efficient circuit design and operation have hampered the adoption and further development of this technology. One critical challenge is the heat dissipation from vertically stacked multiple layers of active devices in a 3-D block. Innovative research into 3-D circuit architectures and advanced heat sink technologies are needed to overcome this difficulty. Another critical challenge is the development of novel design tools to assess three-dimensional placement and routing of the circuit, and the ability to design and synthesize 3-dimensional circuit architectures. DARPA is interested in exploring the feasibility of developing a new generation of CAD tools to enable the design of integrated three-dimensional electronic circuits.

PHASE I: Develop methodologies to analyze and assess coupled electrical and thermal performance of electronic circuits. Develop novel circuit placement and routing algorithms that enable exploration and optimization of 3-D circuit architectures for a given specification. Demonstrate feasibility of designing 3-dimensional circuit architectures that have improved performance, i.e., order of magnitude improvement in interconnect latency with acceptable thermal performance. The Phase I effort will also develop a plan to interface the 3-D design tools with either new or existing design environments in order to validate and demonstrate the methodology in Phase II.

PHASE II: Further develop and extend the tools and concepts developed in Phase I to demonstrate the synthesis and optimization of 3-D circuit architectures. Develop and implement model libraries for 3-D circuit components and sub-blocks/circuits based on coupled thermal/electrical performance characteristics. Develop tools for the coupled optimization of parameters such as integration density, cross talk, interconnect latency and thermal management. The Phase II effort will also implement the plan (developed in Phase I) to interface the 3-D tools with design environments for electronic circuits. Perform verification and validation studies to demonstrate the capabilities of the 3-D design tools. Complete documentation of the 3-D design methodologies, test cases and the test results 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 integrated 3-dimensional electronic circuits. These developments will enable the design of a new generation of integrated circuits with superior interconnect performance, optimized chip areas as well as the ability to integrate mixed technologies in a single block. This will have a significant impact on the design of mixed signal (digital/analog/RF) systems and Systems-on-a-Chip (SoC). Three-dimensional circuit integration will enable novel high performance sensing, communication and processing systems for current and future military requirements. It will also impact commercial applications such as wireless communication systems, optical/optoelectronic devices and systems, etc.

KEYWORDS: Three-Dimensional Integration, Integrated Circuits, Interconnect Latency, Computer-Aided Design, Thermal Management, Mixed Signal Systems.

REFERENCES:
1. Souri, S., Banerjee, K., Mehrotra, A., and Saraswat, K., "Multiple Si Layer ICs: Motivation, Performance Analysis and Design Implications", Proceedings of the 37th Design Automation Conference, Los Angeles, CA, June 5-9, 2000**.**
2. Rahman, A., Fan, A., and Reif, R., "Three-Dimensional Integration: Analysis, Modeling and Technology Development", On-Line MIT Annual Report, http://www-mtl.mit.edu/mtlhome/.
3. Zhang, R., Roy, K., and Jones, D. B., "Architecture and Performance of 3-Dimensional SOI Circuits", IEEE Int. SOI Conf., pp: 44-45, 1999.
4. Rahman, A., Fan, A., Chung, J., and Reif, R., "Wire Length Distribution of Three-Dimensional Integrated Circuits", Proceedings of the International Interconnect Technology Conference, pp: 233-235, 1999.

DARPA SB021-017 TITLE: Wide Bandgap Semiconductor (eg., SiC, GaN) Front-End Electronics for Wide Dynamic Range Analog/Digital Converters

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop wide bandgap semiconductor devices and/or building block circuits, which can be incorporated into wide dynamic range analog/digital converters.

DESCRIPTION: A broad range of defense radar, communications, electronic warfare (EW) and signals intelligence (SIGINT) systems, whether they are land, ship, airborne, space, or handheld could have greatly increased performance if wider dynamic range analog/digital converters (ADC's) were available. Defense analog-to-digital converter (ADC) performance requirements (dynamic range or resolution, sampling rate, center frequency, input analog bandwidth, noise figure, tunability) often **far exceed** the capability of commercial ADC's. Wireless applications are the major commercial driver for ADC development and silicon is the semiconductor material of choice because it provides adequate performance, can be densely integrated with (silicon-based) digital electronics, and is relatively low cost. Although both scaled complementary metal oxide semiconductor (CMOS) and silicon germanium circuits can achieve very high speeds, for many ANALOG OR MIXED-SIGNAL applications such as high resolution ADC's suffer from a major limitation, relatively low breakdown voltage. This problem will get worse, ie., breakdown voltage will continue to decrease, as silicon-based devices are further scaled to achieve the speeds desired in future very fast DIGITAL circuits. Wide bandgap semiconductor (WBS) devices offer the possibility of high speed together with very high breakdown voltage. The initial impetus in WBS circuit research has been to develop high efficiency power amplifiers. By contrast the emphasis here is to investigate the potential of WBS for devices and circuits that are high speed, linear, low noise, wide dynamic range, and can be densely integrated with other semiconductor circuits into analog/digital or digital/analog converters. It is expected that for optimal performance a wide dynamic range converter will contain devices and circuits fabricated from different semiconductor technologies. The question here is what unique contribution can WBS devices and circuits make. The application of the developed circuits for both baseband and bandpass converters are of interest. Examples of important converter goals are ADC's with 16 effective bits, 100 MHz bandwidth and 12 effective bits, several GHz bandwidth.

PHASE I: Devise a feasibility plan for WBS devices which offer potential for significantly improving the dynamic range of very high performance data converters.

PHASE II: Design, fabricate, evaluate, and deliver WBS wide dynamic range devices and/or circuits.

PHASE III DUAL USE APPLICATIONS: The technology developed here will eventually be needed in commercial applications such as telecommunications in high interference environments.

KEYWORDS: Analog/Digital Converters, Digital/Analog Converters, Mixed-Signal Circuits, Wide Dynamic Range Data Converters, Wide Bandgap Semiconductor Devices, Wide Bandgap Semiconductor Integrated Circuits.

DARPA SB021-018 TITLE: VHF/UHF Endo-Clutter SAR Fiducial Marker

ITAR Restrictions Apply

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop a ground-based fiducial marker that can be deployed within foliated areas to aid in the registration of high-resolution, multiple-polarization VHF (very high frequency) and UHF (ultra-high frequency) Synthetic Aperture Radar (SAR) images.

DESCRIPTION: A number of SAR applications (e.g. multi-band fusion, change detection, interferometry and tomography [1]) require very accurate spatial registration of multiple-frequency and/or multiple-pass images. The images can be formed during a single pass of a platform carrying multiple sensors, during multiple imaging passes, or both. Additionally, as in the case of tomography, the radar passes can be made at significantly different aircraft heading angles and/or altitudes. In the extreme case, the images to be registered could view the target area over 360-degrees of azimuth aspect angles and from many different elevation angles. The registration process can be significantly enhanced if accurate "tie points" are available in the SAR images. Surveyed corner reflectors are sometimes placed in the areas being imaged to serve as fiducial markers to aid in the registration process. However, corner reflectors are only effective over a relatively small angular extent and must be very large to have a significant radar cross section at low radar transmit frequencies. DARPA desires to develop a ground-based fiducial marker (either an active or a passive device) that can be placed in an area being imaged to support the automated registration of multiple VHF and UHF SAR images. The marker must support simultaneous imaging at both VHF and UHF, and must be robust to significant differences in grazing angle and sensor heading. Also, the fiducial marker must operate in forested regions as well as in open terrain. The technologies that are used to develop this marker must be compatible with future military and civilian utilizations. DARPA is interested in testing the fiducial marker using the Foliage Penetration (FOPEN) SAR Advanced Technology Demonstration (ATD) system [2]. The FOPEN ATD is dual-band radar, containing a VHF (nominally 25 to 52 MHz) SAR with horizontal polarization and a UHF (nominally 235 to 445 MHz) SAR with simultaneous horizontal, vertical and cross polarization channels. Linear FM (frequency modulation) waveforms are used in both radars. The pulse length varies a function of range and the pulse repetition frequency (PRF) varies a function of the aircraft velocity.

Export Control Warning: ITAR restrictions apply to sensor information that is not provided in Reference [2], as well as to SAR image data.

PHASE I: Conceive an experimental version of the VHF/UHF SAR fiducial marker. Identify risk items that must be demonstrated (e.g. feedback / self-jamming, false triggering, RFI (radio frequency interference), omni-directional coverage)) during the marker testing. Identify any minor modifications that could be made to the SAR ATD system to enhance the performance of the fiducial marker.

PHASE II: Fabricate and demonstrate one or more prototype versions of the VHF/UHF SAR fiducial marker. (Hand placement, field maintenance, etc. are permissible during the demonstration of the experimental version.) Develop concepts for deploying such a fiducial marker to support both commercial and military SAR operations.

PHASE III DUAL USE APPLICATIONS: The fiducial marker will provide a major benefit to both military [3] and commercial [4, 5] VHF/UHF SAR data processing techniques that require multiple image registration. These include the generation of digital elevation models (DEMS), classification of terrain cover for land use evaluation and detection of concealed targets.

KEYWORDS: SAR, Synthetic Aperture Radar, Image Registration, Fiducial Marker.

REFERENCES:

1. Reigber, A. and Moreira, A., "First Demonstration of Airborne SAR Tomography Using Multibaseline L-Band Data, *IEEE Trans. on Geoscience and Remote Sensing*, Sept. 2000.
2. Davis, M. E. et al, "Technical Challenges in Ultra-Wideband Radar Development for Target Detection and Terrain Mapping", *Proceedings of the IEEE International Radar Conf.*, 1999.
3. Sheen, D. R. and Lewis, T. B., "P-3 Ultra-Wideband SAR", *Proceedings of the SPIE*, Vol. 2747, (Conference on Radar Sensor Technology) April 1996.
4. Wheeler, K. and Hensley, S., " The GEOSAR Airborne Mapping System", *Proceedings of the IEEE 2000 National Radar Conference*, Alexandria VA, May 2000.
5. Hellsten, H., et al, "Development of VHF CARABAS II SAR," *Proceedings of the SPIE*, Vol. 2747, (Conference on Radar Sensor Technology), Orlando FL, April 1996.

DARPA SB021-019 TITLE: Airplane Optimal Periodic Flight Control

KEY TECHNOLOGY AREA: Air Platforms; Weapons

OBJECTIVE: Develop and demonstrate optimal periodic flight control algorithms that increase aircraft range performance and endurance performance.

DESCRIPTION: Traditional steady-state airplane cruise, where the vehicle flies at a constant altitude and a constant velocity, is not generally optimal 1. It has been discovered that non-steady type cruise flight profiles will produce more optimal performance. This type of cruise consists of a flight path where the control and state variables behave in a periodic manner. As a result, the trajectory of the aircraft is no longer rectilinear but show a periodic behavior consisting of repeated cycles. Studies have shown that significant range performance and endurance performance can be achieved with optimal periodic trajectories in the subsonic, supersonic and hypersonic flight regimes 2, 3. In the subsonic flight regime, range performance could be enhanced by about 20% and endurance could be enhanced by greater then 50%. The above-mentioned studies have assumed a still atmosphere; that is, real world effect of wind, wind shear, and rising and descending air mass are neglected. In fact, studies 4, 5 have shown that energy in the air can be harvested with periodic flight paths and used to extend a vehicle's range and endurance performance. For aircraft that are flying in the low subsonic regime, this flight technique could greatly increase performance many fold. A single cycle of a periodic flight path can be conceptually divided into two phases. In the first phase, the vehicle thrust is at its maximum. Maximum thrust is greater then the vehicle drag which results in an increase in the vehicle's energy. The energy is invested into the vehicle's altitude and velocity. The second phase, with thrust at a minimum, takes the energy achieved in the first phase and uses it to gain as much range as possible. Better overall performance is achieved because energy added per fuel consumed during phase 1 of the periodic trajectory is much higher than is possible for steady state cruise. There are a number of military and commercial missions that can take advantage of optimal periodic control. In many cases, a physical change to the airplane is not necessary, only a change in the flight path flown. The concept of periodic cruise (Dynamic Soaring) is indeed an idea that has been around for more than 30 years; however, it has never truly been evaluated in practice. This SBIR attempts to conduct a sequence of flight tests at subsonic speeds to validate this idea on a fleet of unmanned air vehicles (UAV's). UAVs are chosen because they represent future battlefield platforms for reconnaissance and delivery of weapons. More importantly, it is only recently that UAVs have reached a level maturity where automated non-conventional flights trajectories can be programmed to do a variety of functions. One of the key issues associated in using UAVs is long-range endurance. This technique of dynamic soaring may enhance the endurance of these vehicles that fly at subsonic, supersonic and hypersonic speeds. Again, from academic studies it appears that the greatest benefit may be at hypersonic speeds, however, validation in this flight regime is not economic nor does the technology fully exist to evaluate this concept. The risk associated with this project is in the level of automated coordination of vehicle engine parameters, control surface deflections and flight control to achieve optimal fuel-efficient flight. Hence the ability to demonstrate this technology would be critical evidence that would support future operation of high-speed vehicles including missiles, and long range bombers that may be programmed to fly periodic trajectories to carry more payloads for greater distances. This topic seeks to develop automatic flight control algorithms to enable airplanes to take advantage of this type of flight control. A successful proposal will develop a strategy for sensing various technical parameters, (i.e.: wind, shear, air data, loads, engine, etc.) and use this data in a flight control algorithm to achieve a particular performance objective. Reasonable performance objectives could be, but are not limited to, range, speed/range, endurance, mean speed, total heat load, etc. Since the objective of the topic is to develop a practical flight control system, reasonable flight constraints must be considered as part of the demonstrated concept. It is also reasonable for a successful proposal to identify and demonstrate strategies for applying periodic flight control to aircraft designed to optimize the advantages of non-steady state flight rather than to design along traditional lines.

PHASE I: Characterize the advantage of optimal periodic flight control and perform a structured flight experiment to demonstrate proof of concept.

PHASE II: Develop and flight test flight control algorithms to implement optimal periodic flight control into existing manned and unmanned aircraft.

PHASE III DUAL USE APPLICATIONS: There are many UAV military missions that wish to maximize vehicle endurance. There are also many manned aircraft missions that require maximum loiter capability. A periodic flight control law would give these aircraft an immediate gain in performance. There are also many proposed commercial and government agency missions that need a slow subsonic vehicle to loiter for long periods. This technology would have direct application.

KEYWORDS: Reduced Fuel Consumption, Optimal Cyclic Cruise, Optimal Cruise, Periodic Flight, Optimal Periodic Flight, Periodic Flight Control, Improving Airplane Performance.

REFERENCES:

1. Speyer, J. L., "On the Fuel Optimality of Cruise," Journal of Aircraft, Vol. 10, Dec. 1973, pp. 763-765.
2. Sachs, G., and Christodoulou, T., "Reducing Fuel Consumption of Subsonic Aircraft by Optimal Cyclic Cruise," Journal of Aircraft, Vol. 24, No. 9, pp.616-622.
3. Speyer, J. L., "Periodic Optimal Flight," Journal of Guidance, Control, and Dynamics, Vol. 19, No. 4, pp. 745-755.
4. Reynolds, O., "The Soaring of Birds," Nature, Vol. XXVII, p. 534.
5. Wilson, J. A., "Sweeping Flight and Soaring by Albatrosses," Nature, Vol. 257, p. 307.

DARPA SB021-020 TITLE: Water-Based Thrusters for Space Propulsion

KEY TECHNOLOGY AREA: Space Platforms

OBJECTIVE: Design, build, and test innovative space satellite thrusters using water or its constituent gases as a fuel (propellant) and having high specific thrust.

DESCRIPTION: Space satellites maneuver to maintain orbit and to move from one orbit to another. It is envisioned that future military space satellites will be required to do far more maneuvering than current satellites, that the propellant required for maneuvering will be treated as a consumable item to be replaced several times during the lifetime of a satellite, and that water will be the only propellant for the thrusters. The water will be used as a propellant in two ways, directly in liquid form and converted to hydrogen and oxygen gases. Ongoing research (Ref. 1) will develop a regenerative fuel cell system to handle the water and convert it to the constituent gases. Several kinds of thrusters have been demonstrated (Ref. 2), some of which may work on water. The objective of this topic is to develop innovative thrusters specifically for use with water or its constituent gases as a propellant. Thrusters are needed for all kinds of maneuvering. Electrically powered thrusters with very high specific impulse (thousands of seconds) will be applied to major changes to orbit. Thrusters with reduced electric power requirements (< 1 Watt / mN) or that burn the hydrogen and oxygen will be applied for more rapid maneuvering. Thrusters with intermediate performance levels are also required. Since thrusters operate at high temperatures, lifetime is an important issue.

PHASE I: Identify design requirements for the thruster, model its performance, show through analysis a usefully high level of performance, perform critical experiments on the functionality of the thruster using water or its constituent gases, and identify the key issues for demonstration in Phase II.

PHASE II: Establish in detail the design requirements and the performance model, build and test critical components of the thruster, build and demonstrate a working thruster, and show that it can operate reliably over a long lifetime.

PHASE III DUAL USE APPLICATIONS: The military application of water-based thrusters is to satellites that must maneuver frequently or will have a long lifetime during which they will be refueled and serviced. Frequent maneuvering may be required for tactical surveillance of changing threats. The commercial world has the analogous need to change areas of coverage, for example, in response to news events. Also, it may be practical to maneuver a satellite into place to cover for a failing geosynchronous satellite.

KEYWORDS: Space Propulsion, Satellites, Thrusters, Electric Thrusters.

REFERENCES:

1. http://www.darpa.mil/TTO/wbps/baa01-23.html
2. http://eis.jpl.nasa.gov/sec353/apc/index.html

DARPA SB021-021 TITLE: Tracklet Fusion for strategic GMTI

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop methods for associating short duration track files (tracklets) in order to maintain situational awareness on high priority targets, such as transportable erector launchers (TELs). For non-defense scenarios might consist of vehicles as part of the smart highway initiative, animals in wildlife tracking, or air vehicles in collision avoidance.

DESCRIPTION: Ground Moving Target Indication (GMTI) holds the promise of providing dominant situational awareness on specified targets of interest. In a military context these would be for maneuver warfare, as well as indications and warning during preconflict periods. The presence of terrain obscuration and foliage, as well as micro obscuration (buildings, tunnels, overpasses), combined with target fluctuation generally leads to less than ideal track duration. For strategic GMTI, whereby one seeks to maintain overall situational awareness as opposed to targeting movers directly, there is a potential solution: mainly to associate tracklets to obtain a fused data product. As an example application suppose one seeks to determine the presence of TELs in a given region. One might obtain tracklets, which in isolation have a probability of corresponding to a TEL, which is suggestive but not conclusive (say 80% confidence). If one can associate tracklets based on behavior, terrain, and range profiles one can boost the confidence through a process analogous to incoherent gain in radar dwells. Note that the intent of tracklet fusion is not maximizing track duration but rather tracklet information. This might suggest a different operating point in the tracker is desired; say longer dwells, higher bandwidth, or possibly tighter association windows. These will disallow long track duration (for fixed area rate) but may allow better post track fusion. In addition synthetic aperture radar (SAR) imaging may be desired in an interweave configuration. While the above discussion motivates tracklet fusion in the warfighter context the ability to associate track segments through significant gaps have dual use applications as outlined below.

PHASE I: Develop a theory of tracklet fusion, and develop design tools to determine optimal track parameters. Construct a simulation testbed to evaluate the situational awareness achievable in tracklet fusion using realistic foliage and terrain obscuration models. Include models for high-resolution range profiling, including confusion matrices as a function of bandwidth and signal-to-noise ratio (SNR). Develop a track fusion software testbed and determine the size of a reference area one can “cleanse” for high value targets using several radar models, e.g. Jstars, Global Hawk, and Discoverer II.

PHASE II: Apply the track fusion software to ground truthed data testbeds. Determine robustness to, and the degree of degradation from, clutter discretes, geolocation biases, etc.

PHASE III DUAL USE APPLICATIONS: Commercial applications include law enforcement applications for tracking noncompliant targets.

KEYWORDS: Ground Moving Target Indication (GMTI), SAR, Synthetic Aperture Radar, Dominant Situational Awareness, High Resolution Range Profiling, Feature Aided Tracking, Data Fusion.