**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**
**FY2009.1 SBIR Proposal Submission**

DARPA's mission is to prevent technological surprise for the United States and to create technological surprise for its adversaries. The DARPA SBIR and STTR Programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.

The responsibility for implementing DARPA's Small Business Innovation Research (SBIR) Program rests with the Innovative Research Office.


**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**
**Attention: DIRO/SBIR/STTR**
**3701 North Fairfax Drive**
**Arlington, VA 22203-1714**
**(703) 526-4170**
**Home Page http://www.darpa.mil**


Offerors responding to the DARPA topics listed in Section 8.0 of this solicitation must follow all the instructions provided in the DoD Solicitation Instructions preface. Specific DARPA requirements in addition to or that deviate from the DoD Solicitation Instructions are provided below and reference the appropriate section of the DoD Solicitation Instructions. All proposals must be submitted electronically through the DoD SBIR Web site at http://www.dodsbir.net/submission by the submission deadline. Proposals provided in hard copy or via e-mail will not be accepted. In addition, all topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be accepted.

## SPECIFIC DARPA REQUIREMENTS:

### 2.15 Foreign National

DARPA topics are unclassified; however, the subject matter may be considered to be a "critical technology" and may be subject to ITAR restrictions. 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. See **Export Control** requirements below in Section 5.

### 3.7 Phase II Proposal Format

DARPA Program Managers may invite Phase I performers to submit a Phase II proposal based on the technical results reflected in the Phase I contract and/or final reports. Phase II proposals will be evaluated in accordance with the evaluation criteria provided in Section 4.3.

### 4.0 Method of Selection and Evaluation Criteria

The offeror's attention is directed to the fact that non-Government advisors to the Government may review and provide support in proposal evaluations during source selection. Non-government advisors may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. These advisors will not establish final assessments of risk and will not rate or rank offeror's proposals. They are also expressly prohibited from competing for DARPA SBIR or STTR awards in the SBIR/STTR topics they review and/or provide comments on to the Government. All advisors are required to comply with procurement integrity laws and are required to sign Non-Disclosure and Rules of Conduct/Conflict of Interest statements. Non-Government technical consultants/experts will not have access to proposals that are labeled by their proposers as "Government Only".

## 4.2 Evaluation Criteria

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives twice the weight to Criterion A. "The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution." Please note that proposals that scored low on evaluation Criterion C. "The potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization" were considered weaker proposals. 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 proposals is deemed superior and are highly relevant to the DARPA mission, 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.

## 4.4 Assessing Commercial Potential of Proposals

DARPA is particularly interested in the potential transition of SBIR project results to the U.S. military, and expects explicit discussion of a transition vision in the commercialization-strategy part of the proposal. That vision should include identification of the problem, need, or requirement in the Department of Defense that the SBIR project results would address; a description of how wide-spread and significant the problem, need, or requirement is; identification of the potential end-users (Army, Navy, Air Force, SOCOM, etc.) who would likely use the technology; and the operational environments and potential application area(s).

Technology commercialization and transition from Research and Development activities to fielded systems within the DoD is challenging. Phase I is the time to plan for and begin transition specific activities. The small business must convey an understanding of the transition path or paths to be established during the Phase I and II projects. That plan should include the Technology Readiness Level (TRL) at the start and end of the Phase II. The plan should also include a description of targeted operational environments and priority application areas for initial Phase III transition; potential Phase III transition funding sources; anticipated business model and identified commercial and federal partners the SBIR company has identified to support transition activities. Also include key proposed milestones during the project that include, but are not limited to: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.

## 4.5 SBIR Fast Track

- DARPA encourages Phase I performers to discuss its intention to pursue Fast Track with the DARPA Program Manager prior to submitting a Fast Track application or proposal. Selection of a Fast Track proposal is not mandated and DARPA retains the discretion to not select or fund any Fast Track proposal.
- After coordination with the DARPA Program Manager, the performer and the investor are required to submit a Fast Track application through the DoD Submission Web site no later than the last day of the 6th month of the Phase I effort.
- The Fast Track Interim amount is not to exceed $40,000.
- The performer must submit its Phase II proposal before the last day of the 7th month of the Phase I effort.

## 4.6 Phase II Enhancement Policy

DARPA will provide a Phase II performer up to $200,000 of additional Phase II SBIR funding if the performer can match the additional SBIR funds with non-SBIR funds from DoD core-mission funds or the private sector.

Generally, the additional Phase II funds are applied to the Phase II contract. Phase II Enhancements are subject to the availability of funds.

## 4.7 Commercialization Pilot Program

DARPA does not participate in the Commercialization Pilot Program (CPP); however, DARPA has established a Transition Support Pilot Program focused on transitioning innovative technologies to the most critical U.S. military end-users as well as key collaboration partners. This program will also support transitions within DARPA, civilian agencies, and private-sector, if deemed critical for technology transition success. The program, administered by the DARPA SBIR Program Office with support from The Foundation for Enterprise Development (The Foundation), a U.S. owned non-profit organization, consists of the following assistance:

- Transition Assistance. The Foundation will provide DARPA funded SBIR Phase II companies identified to participate in the Pilot with guidance and assistance in identifying and facilitating introductions to potential collaborators, funding sources, and end users, in support of SBIR Company's Phase III technology development activities. Thus, identification of potential funding sources will be primarily focused on enabling the SBIR Company to work towards reaching Technology Readiness Level (TRL) 7 – System prototype demonstration in an operational environment. Specific potential funding sources will be identified throughout a designated period of transition support and may include, but are not limited to:
  - DARPA
  - Other DoD research programs (e.g.: Army, Navy, Air Force, Marine Corps)
  - Prime contractor programs, to include their Independent Research & Development (IR&D) programs
  - Non-DoD Federal research programs in the Intelligence agencies and the Department of Homeland Security
  - Other non-DoD Federal research programs, such as those within National Institutes of Health
  - Other DoD-funded technology transition programs as appropriate (e.g., Technology Transition Initiative, Defense Acquisition Challenge, TechLink and TechMatch)
  - Venture capital funding sources

To be eligible for assistance, the SBIR Company must have an active Phase II, expected technology readiness level of 5 or greater at the completion of Phase II, and understanding of and progress within the expected transition path or paths. DARPA retains the discretion to not select a company. Each identified company will execute a Technology Transition Agreement with the contractor to initiate support. Participation in the DARPA Technology Transition Pilot Program is voluntary.

- All obligations of the SBIR Company shall be carried out at no cost to The Foundation or DARPA and are not billable to any SBIR contract. The SBIR Company shall make relevant experts reasonably available to The Foundation to discuss potential application areas for the technology under development and to support the execution of the technology transition support services described above. The SBIR Company also shall make its relevant experts available for follow-up discussions and briefings with potential collaborators or representatives from federal or other potential funding sources. As appropriate, the SBIR Company will develop appropriate company profiles, briefings and other types of informational materials to support discussions and briefings. SBIR companies involved in the transition pilot will be asked for feedback on the assistance provided upon completion of the Phase II and on transition outcomes within the year following the Phase II.

- Success Reports: The Foundation will document company Phase III transition successes individualized reports as well as or other printed material for distribution at outreach events and for posting on the DARPA SBIR Web site. SBIR companies that have received Phase III funding are eligible to work with The Foundation to develop the success report. Cleared

Success Reports will continue to be posted on the DARPA SBIR Web site. The 2007 DARPA SBIR Success Reports can be viewed at this link: http://www.darpa.mil/sbir/Success_Story_Main_Page.htm

- Outreach/Process Improvement: The Foundation will capture lessons learned, program feedback and best practices from SBIR companies, and will help develop and implement process improvements to increase transition success for DARPA SBIR funded companies. Transition outreach includes panel presentation and one-on-one meetings at selective SBIR conferences. Additional transition–related documentation and links will be available upon request and via the SBIR web site in the future. All active DARPA SBIR companies are eligible for this outreach support.

- Phase III transition support is subject to the availability of funds.

**5.1.b. Type of Funding Agreement (Phase I)**

- DARPA Phase I awards will be Firm Fixed Price contracts.
- Companies that choose to collaborate with a University must highlight the research that is being performed by the University and verify that the work is FUNDAMENTAL RESEARCH.

**5.1.c. Average Dollar Value of Awards (Phase I)**

DARPA Phase I proposals **shall not exceed $99,000,** and are generally 6 months in duration. Phase I contracts will not be extended.

**5.2.b. Type of Funding Agreement (Phase II)**

- DARPA Phase II awards will be Cost Plus Fixed Fee contracts. However, DARPA may choose to award a Firm Fixed Price Phase II contract on a case-by-case basis.
- Companies that choose to collaborate with a University must highlight the research that is being performed by the University and verify that the work is FUNDAMENTAL RESEARCH.

**5.2.c. Average Dollar Value of Awards (Phase II)**

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.

**5.3 Phase I Report**

All DARPA Phase I and Phase II awardees are required to submit a final report, which is due within 60 days following completion of the technical period of performance and must be provided to the individuals identified in Exhibit A of the contract. Please contact your contracting officer immediately if your final report may be delayed.

**5.11.r. Export Control**

The following will apply to all projects with military or dual-use applications that develop beyond fundamental research (basic and applied research ordinarily published and shared broadly within the scientific community):

(1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for

obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

(2) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at any Government installation (whether in or outside the United States), where the foreign person will have access to export-controlled technologies, including technical data or software.

(3) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(4) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

**Please visit http://www.pmddtc.state.gov/regulations_laws/itar.html for more detailed information regarding ITAR requirements.**

**5.11.s. Publication Approval**

There shall be no dissemination or publication, except within and between the Contractor and any subcontractors, of information developed under this contract or contained in the reports to be furnished pursuant to this contract without prior written approval of the DARPA Technical Information Officer (DARPA/TIO). All technical reports will be given proper review by appropriate authority to determine which Distribution Statement is to be applied prior to the initial distribution of these reports by the Contractor. Papers resulting from unclassified contracted fundamental research are exempt from prepublication controls and this review requirement, pursuant to DoD Instruction 5230.27 dated October 6, 1987. Any publications shall incorporate an Acknowledgement of Support and Disclaimer in accordance with FAR 252.235-7010.

The following provision will be incorporated into any resultant contract:

When submitting material for written approval for open publication as described above, the Contractor/Awardee must submit a request for public release to the DARPA TIO ***5 weeks prior to the event.*** Requests received with a due date of less than five weeks lead time require a justification. Unusual electronic file formats may require additional processing time. Include the following information:

1) Document Information: document title, document author, short plain-language description of technology discussed in the material (approx. 30 words), number of pages (or minutes of video) and document type (briefing, report, abstract, article, or paper);

2) Event Information: event type (conference, principle investigator meeting, article or paper), event date, desired date for DARPA's approval;

3) DARPA Sponsor: DARPA Program Manager, DARPA office, and contract number; and

4) Contractor/Awardee Information: POC name, e-mail and phone.

Requests can be sent either via e-mail to tio@darpa.mil or via surface mail to 3701 North Fairfax Drive, Arlington VA 22203-1714, telephone (571) 218-4235. Refer to http://www.darpa.mil/tio for information about DARPA's public release process.

**5.14.h. Human and/or Animal Use**

This solicitation may contain topics that have been identified by the program manager as research involving Human and/or Animal Use. In accordance with DoD Policy, human and/or animal subjects in research conducted or supported by DARPA shall be protected. Although these protocols will most likely not be needed to carry out the Phase I, significant lead time is required to prepare the documentation and obtain approval in order to avoid delay of the Phase II award. Please visit http://www.darpa.mil/sbir/ to review the Human and Animal Use PowerPoint presentation(s) to understand what is required to comply with human and/or animal protocols.

- **Human Use:** All research involving human subjects, to include use of human biological specimens and human data, selected for funding must comply with the federal regulations for human subject protection. Further, research involving human subjects that is conducted or supported by the DoD must comply with 32 CFR 219, Protection of Human Subjects (http://www.dtic.mil/biosys/downloads/32cfr219.pdf), and DoD Directive 3216.02, Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research (http://www.dtic.mil/whs/directives/corres/pdf/321602p.pdf ).

- **Animal Use:** Any Recipient performing research, experimentation, or testing involving the use of animals shall comply with the rules on animal acquisition, transport, care, handling, and use in: (i) 9 CFR parts 1-4, Department of Agriculture rules that implement the Laboratory Animal Welfare Act of 1966, as amended, (7 U.S.C. 2131-2159); (ii) the guidelines described in National Institutes of Health Publication No. 86-23, "Guide for the Care and Use of Laboratory Animals"; (iii) DoD Directive 3216.01, "Use of Laboratory Animals in DoD Program."

**6.3 Notification of Proposal Receipt**
DARPA will send each offeror an e-mail acknowledging receipt of proposal after the solicitation closing date.

**6.4 Information on Proposal Status**
All letters notifying offerors of selection or non-selection will be sent via e-mail to the person listed as the "Corporate Official" on the proposal.

**6.5 Debriefing of Unsuccessful Offerors**
DARPA will provide each unsuccessful offeror an automatic debriefing summary as an enclosure to the notification of non-selection.

## DARPA SBIR 091 Topic Index

| | |
|---|---|
| SB091-001 | Multiferroic Approach to Heat Pumps |
| SB091-002 | Wideband Photonic Sensor System |
| SB091-003 | Geosocial Inference for Stability and Reconstruction Operations (GISARO) |
| SB091-004 | Hyperspectral Imaging Sensor Based Feature Aided Tracking |
| SB091-005 | UV to SWIR Broadband Focal Plane Array Sensor |
| SB091-006 | Nanoengineered LWIR Bolometers |
| SB091-007 | Integrated Low Jitter Mode Locked Lasers |
| SB091-008 | Design and Fabrication Techniques for 3-Dimensional Integrated Circuits |
| SB091-009 | High-Resolution Imaging of Large Field-of-View Scenes |
| SB091-010 | Panoramic Helmet-Mounted Display and Processing |
| SB091-011 | Submarine Pressure Hull Tomography |
| SB091-012 | Robust Distributed GPS Apertures |
| SB091-013 | High Energy Micro Rocket Stages for Tactical & Space Applications |
| SB091-014 | Personal Air Vehicle Technology |

# DARPA SBIR 091 Topic Descriptions

SB091-001 TITLE: Multiferroic Approach to Heat Pumps

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: The objective of this topic is to develop and demonstrate solid state heat engines based on multiferroic composites that can compete on the basis of efficiency and power density with thermoelectric devices.

DESCRIPTION: Recently it has been recognized that very strong cross-coupling between electric and magnetic properties can be realized in composites of ferroelectrics and magnetic materials which are strain coupled. Work in this area has recently been reviewed (1, 2). The goal of this topic is to develop innovative multiferroic composites which can be used for heat pumps. Combinations of magnetocaloric and electrocaloric materials offer the potential to design electric field actuated heat pumps and significantly reduce the mass of magnetic refrigerators through elimination of magnets. The strain coupled magnetocaloric and ferroelectric or piezoelectric materials may also enable solid state thermoacoustic stirling engines which would operate at high frequency and therefore have high power density.

The magnetocaloric effect is the change in temperature of a magnetic material with a change in magnetic field. Magnetic refrigerators utilize this effect for cooling. An example of research in this area is given in reference 3. A goal of this topic is to use strain (magnetostriction) instead of a change in magnetic field to generate a temperature change. Multiferroics can be used to apply a strain to a magnetic phase using a strain coupled ferroelectric with an applied electric field. Another type of refrigerator is the thermoacoustic Stirling engine (4, 5). Thermoacoustic Stirling cycle coolers (4, 5) use acoustic power to pump heat from low temperature to higher temperature sinks. They typically operate by transferring the adiabatic heat of compression of an acoustic wave in a high pressure helium chamber with a heat-transfer stack. The thermoacoustic refrigeration systems move thermal energy like a bucket brigade along the heat transfer stack. The higher operating frequency of a solid state equivalent of an acoustic refrigerator would enable design of more compact refrigerators/coolers. Another goal of this topic would be to design an all solid state version of the acoustic refrigerator using multiferroic composites. For the purposes of this topic, the design parameters (temperatures of source and sink, and cooling capacity) will be 300 watts pumped between 50 degrees C and 21 degrees C which would be useful cooling for an individual soldier wearing chemical-biological protective gear. Quantitative performance goals for the proposed application must be stated in the proposal along with competitive benchmarks for conventional cooling approaches.

PHASE I: Define and develop key component technological milestones for a multiferroic based heat pump with no moving parts and establish its technical feasibility through quantitative physics based modeling. The design should include a thermodynamic model, identification of the materials of construction along with their figures-of-merit for the system level performance, and the control circuit for operation of the device as appropriate. The preliminary design should also include a detailed physics based computer-aided design model to predict the performance of the heat pump and benchmark against alternative heat pump systems.

PHASE II: Construct and demonstrate the operation of a prototype as designed in Phase I and measure its performance. The prototype should be fully instrumented and flexible enough to explore the control parameters (Voltage, frequency, magnetic field, temperature, etc.) on performance metrics (efficiency, weight specific cooling capacity, etc.). Required Phase II deliverables will include: (1) a working prototype of a portable cooler suitable for cooling an individual soldier, (2) drawings and specification for its construction, and (3) test data on its performance.

PHASE III DUAL USE APPLICATIONS: Compact, reliable, environmentally friendly and efficient cooling devices will have broad application in automotive and home air conditioning systems. Industrial applications include cooling of semiconductor chips. The potential to replace conventional systems which leak ozone depleting chlorofluorocarbons is significant. Defense applications include thermal management onboard satellites, coolers for IR focal plane arrays, and cooling for personnel in chem.-bio protective suits.

REFERENCES:

1. M. I. Bichurin, D. Viehland and G. Srinivasan, "Magnetoelectric interactions in ferromagnetic-piezoelectric layered structures: Phenomena and devices," Journal of Electroceramics. Vol.19, No.4 December 2007, pp243-250

http://www.springerlink.com/content/g66306167vx83717/.

2. Ce-Wen Nan, M. I. Bichuin, Shuxiang Dong, D. Viehland, G. Srinivasan, “Multiferroic magnetoelectric composites: Historical perspectives, status, and future directions“, Journal of Applied Physics. (Applied Physics Reviews-Focused Review) Vol.103, No.031101 February 2008.

3. K. A. Gschneider Jr., V.K. Pecharsky. A.O. Pecharsky, and C.B. Zimm, “Recent Developments in Magnetic Refrigeration”, Materials Science Forum, ‘Rare’ Earths ‘98’. Vols.315-317 (1999), pp. 69-76.

4. Steven L. Garrett and Scott Backhaus, “The Power of Sound”, American Scientist. Vol.88, No. 6 November-December 2000.

5. R.S. Reid, G.W. Swift, “Experiments with a flow-through thermoacoustic refrigerator”, Journal of the Acoustic Society of America. Vol.108 (6) December 2000, pp. 2835-2842.

KEYWORDS: Multiferroic, cooler, heat pump.

SB091-002 TITLE: Wideband Photonic Sensor System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate photonic techniques to permit the simultaneous transmission and reception (STAR) of diverse RF signals through a very wideband aperture.

DESCRIPTION: As military systems increasingly rely upon distributed RF sensors for communications and surveillance, it is becoming increasingly difficult to arrange the scheduling of sensing functions so that the transmission and reception functions do not overlap. Hence it will become vital that future military wireless systems have the ability to “look through” transmission signals; i.e., they must be able to receive during transmission. Perhaps the most stressing situation for simultaneous transmit and receive is the ability to receive even during a system’s own transmission of signals. Because on many platforms the space for antennas is limited, there is the need to use the same aperture for both transmit and receive functions.

The need to do STAR will have ramifications throughout the surveillance/ communications system design. The design and implementation of transmit-receive (T/R) modules will be particularly challenging for new platforms that require remote installation, along with significant reduction of size, weight and power (SWAP). Photonics have promised to be a key enabling technology for distribution of signals, as well as the active transmission and reception of signals. Some of the key T/R module performance metrics for STAR are bandwidth, receive noise figure and transmit-receive isolation. Since bandwidth greater one decade is often required, there is a need for alternative technologies to a conventional RF circuits to provide isolation and preselection for signal processing. The overall objective of the STAR development is: Bandwidth greater than one decade; receive noise figure less than 6 dB; T/R isolation greater than 40 dB across the bandwidth.

PHASE I: Design a Simultaneous Transmit and Receive (STAR) T/R module utilizing photonic technology with the capability of providing simultaneous transmission and reception of RF signal over a wide bandwidth. Identify a technology development path to achieving these goals within a system application combining radar, passive direction finding and communications in a crowded signal environment. As part of the final report, plans for Phase II will be proposed.

PHASE II: The design from Phase I will be verified by a combination of modeling and simulation and limited experiments with key components. A breadboard STAR T/R module will be fabricated and tested in a non-form factor to verify the performance measures from Phase I. Critical characteristics should be demonstrated with simulated environments. A system application approach will be designed and performance predictions made based on the component parameter measurements.

PHASE III DUAL USE APPLICATIONS: Some of the frequency bands required for military applications are also shared by commercial wireless systems, such as for communicating between satellite and ground stations. Hence this technology could be applied to satellite communications systems, which would double the bandwidth because the previously separate transmit and receive bands could then be used for both transmit and receive.

REFERENCES:

1. K Garenaux et al, Recent Breakthroughs in RF Photonics for Radar Systems IEEE AES Systems Magazine February 2007, p 3.

2. S Pappert, B Krantz, RF Photonics for Radar Front Ends, Proc 2007 IEEE Radar Conference, April 2007, p. 965.


KEYWORDS: Multiple Sensor Exploitation, CC&D.

SB091-003 TITLE: Geosocial Inference for Stability and Reconstruction Operations (GISARO)

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a novel system that facilitates collaboration between members of local military and civilian communities to support stability and reconstruction operations.

DESCRIPTION: Military stability and reconstruction operations (SARO) include humanitarian activities such as the repair of schools, construction of roads, maintenance of hospitals. In addition, SARO involves response to emergencies and support to local communities in providing medical, police, and refugee services. Collaboration between members of the local civilian and military communities is not only mutually beneficial but in many cases necessary for the successful fulfillment of SARO objectives. While the roles and responsibilities of military personnel for various types of SARO are well-defined, the processes for engagement with members of the civilian community have considerably less doctrine associated with them. This presents a “geosocial” challenge to military leaders seeking support from civilians with the expertise and interests relevant for a particular SARO.

DARPA is interested in developing a Geosocial Inference for Stability and Reconstruction Operations (GISARO) system that facilitates the interaction between members of local military and civilian communities based on their location, influence, and interests. GISARO would incorporate geospatial knowledge with information about local customs and social structures to provide decision support for SARO commanders. GISARO would be capable of answering the "Five W's and One H" pertaining to the civilian geosocial aspects of a SARO: who to communicate with, what information they need, when to approach them, where to meet them, why their support is vital, and how they may interact with military personnel. GISARO would also hypothesize complex activity workflows composed of civilian and military community members that best accomplish a particular SARO, i.e., the appropriate sequence of social interactions for meeting the SARO objectives. The system would potentially leverage emerging knowledge representation, machine learning and reasoning, geographic information systems, social networking service, semantic web, and collaboration technologies to achieve these technical goals.

Proposed research in the initial phase of this effort should focus on demonstrating, in a rigorously empirical and quantitative fashion, the capability of the offeror’s technical approach. Offerors must identify the SARO types their approaches are intended to support and design experiments accordingly. Offerors must also clearly indicate the data sources they propose to use for development and testing, the query types (i.e., which “W” or “H”) on which will they will concentrate, and metrics they will use to measure the performance of the system.

PHASE I: Investigate viability and design approaches GISARO technology. Validate through experimentation with simulated data. Evaluate potential benefit to military operations and commercial applications.

PHASE II: Apply Phase I results, data, and analysis to develop a prototype that demonstrates the efficacy of GISARO technology. Evaluate the performance of prototype through experimentation on operationally realistic data.

PHASE III DUAL USE APPLICATIONS: GISARO technology will provide unique local collaboration capabilities for military, government, and commercial organizations.

REFERENCES:
1. Gerbik, Keith D. (Ed.). (2007). Peacekeeping and Stability Issues. Nova Science Publishers.

2. Scharl, Arno and Tochtermann, Klaus (Eds.) The Geospatial Web: How Geobrowsers, Social Software and the Web 2.0 are Shaping the Network Society. London: Springer.

KEYWORDS: Stability and reconstruction operations, semantic web, knowledge representation, machine learning, reasoning, geographic information systems, human terrain, social networking services, Web 2.0, location-based services.

SB091-004 TITLE: Hyperspectral Imaging Sensor Based Feature Aided Tracking

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop advanced techniques in hyperspectral imagery exploitation enabling target fingerprinting and real-time feature aided tracking.

DESCRIPTION: Maintaining long term track of vehicles and people in urban environments remains a difficult problem. Advances in hyperspectral imaging systems, particularly cooled and uncooled long wave infrared systems, provide one possible means of addressing this problem. In particular, anecdotal evidence suggests that it may be possible measure stable and salient spectral signatures of threat dismounts and vehicles that enable matching of object detections and tracks over time, with performance greatly improved relative to kinematic-only matching methods that become confused when targets are closely spaced, occluded, or perform evasive maneuvers. Research is required to develop new methods for signature matching, and to test those methods with vehicle and dismount targets for which data has been collected under different environmental conditions, different geometries, and at different times, enabling matching algorithm performance assessment. In addition, approaches are required for integrating the matching technology into real-time feature aided tracking applications, including methods for hyperspectral sensor control, integration of hyperspectral match scores with kinematic or other matching data, and real-time processing methods.

PHASE I: Develop prototype algorithms to enable signature extraction, matching, and feature aided tracking. Obtain representative long wave infrared hyperspectral datasets. Measure probability of correct signature matching performance and determine feasibility of achieving feature aided track duration performance exceeding one hour. Identify hyperspectral imaging system that provides potential source of transition opportunities.

PHASE II: Collect calibrated, ground truthed hyperspectral datasets of dismounts and vehicles to enable demonstration, refinement of algorithms, and tracking performance calculation. Demonstrate prototype feature aided tracking algorithms under operationally realistic conditions using hyperspectral sensor identified in Phase 1. Determine size, weight, power, and other requirements for algorithm transition.

PHASE III: Integrate algorithms with developmental or operational system. Demonstrate real-time operation.

REFERENCES:
1. Richard Ivey, Joel Horn, Marianne Chiarella, Michael Seibert, and Allen Waxman, "Long Duration Fused Feature Aided Tracking," in the Proceedings of the Military Sensing Symposia (MSS), National Symposium on Sensor & Data Fusion (NSSDF), Monterey, 2005.

The referenced publication is located in the DTIC TEMS database, which is available to anyone registered with DTIC.
The reference may be obtained from the Military Sensing Information Analysis Center (MSIAC) in Atlanta,GA.
Contact information:
phone-404-407-7367; FAX: 404-407-9372; email: sensiac@gtri.gatech.edu.
In requesting this publication you should refer to the file name:
SENS-NSSDF-052005-SE04.

KEYWORDS: Hyperspectral imaging, adaptive signal processing, feature extraction and matching, dismount and vehicle tracking.

SB091-005 TITLE: UV to SWIR Broadband Focal Plane Array Sensor

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop, fabricate and test a 256x256 UV to SWIR broadband focal plane array sensor with integrated spectral binning and imaging capabilities. Demonstrate techniques capable of achieving multispectral image sensing capability in single material system with small mass, volume and power requirement.

DESCRIPTION: An optical sensor, capable of measuring multispectral bands within 0.25 to 2.5 micrometer range is required. Today, separate sensors/materials are used for different sub-bands within the UV to SWIR wavelength range. A monolithic sensor/detector with multispectral detection capability would offer a multitude of military and commercial applications, including chemical and bio-molecule sensing, image sensing, communication etc. In general GaN, Si and InGaAs based detectors are used for the three important sub-bands, 0.25-0.4 (UV), 0.45-0.8 (Visible) and 0.9-1.7 (NIR), respectively. The goal of this program is to include an additional 1.7-2.5 (SWIR) sub-band and develop an integrated single broadband detector with spectral sub-band binning and imaging capabilities. The features of the desired multi-color detector should have simple structure, low-cost, high quantum efficiency, high sensitivity, and high speed over broad spectral ranges from UV to SWIR. Detector fabrication in a single material system is preferred to simplify design and to maintain a lower manufacturing cost. Therefore, innovations in designing novel detector architectures are necessary. Strategy to extend cut-on wavelength to UV and cut-off wavelengths to SWIR in a single material system must consider consequences of related noise, sensitivity and resolution. Further, consideration must be given for the transmission loss due to an integrated spectral binning in the sub-band regions. The overall design, therefore, must evaluate the signal to noise ratio for each sub-bands and related focal plane array characteristics.

PHASE I: Develop approaches for an integrated UV-SWIR broadband detector architecture with sub-band spectral binning capability. Perform modeling and simulation to analyze initial concept design, performance goals and key parameters. Fabricate a single detector and demonstrate current-voltage characteristics for all sub-bands.

PHASE II: Select and finalize the best design achieved in Phase I, in order to optimize performance parameters through experiments. Characterize broadband response to evaluate quantum efficiencies in each sub-band. Extend single detector design to develop and fabricate a 256x256 detector array. Integrate sub-band (could be narrower than sub-band defined) binning capability and test the focal plane array prototype. Required Phase II deliverables will include a prototype 256x256 array with complete characterization report.

PHASE III DUAL USE APPLICATIONS: Several units of the broadband detector arrays will be manufactured and a series of qualification tests will be performed to validate the design and its performance. This technology has broad applications in military and various commercial sectors. The commercialization of this technology is expected to provide low cost, high performance mega-pixel imagers for potential uses in applications such as automobile, security/law enforcement, medical imaging, border patrol, homeland security as well as military applications such as multipurpose imaging, rifle sight, chemical & biological detection, etc.

REFERENCES:
1. G. Lucovsky, R. F. Schwarz, and R. B. Emmons, “Transit-time consideration in p-i-n diodes.” J. Appl. Phys., 35, pp.622-628, 1964.

2. R. G. Smith and S. D. Personick, “Receiver design for optical communication systems,” in Semiconductor Devices for Optical Communication, 2nd ed., pp.89-160, H. Kressel-Springer-Verlag, New York, 1982.

3. M. K. Emsley, O. Dosunmu, and M. S. Ünlü, “Silicon substrates with buried distributed Bragg reflectors for resonant cavity-enhanced optoelectronics,” IEEE J. Selected Topics in Quantum Electron., 8(4), pp. 948-955 (2002).

4. A. K. Dutta, M. Takechi, R. S. Virk, M. Kobayashi, K. Araki, K. Sato, M. Gentrup, and R. Ragle, “40 Gb/s Postamplifier and PIN/preamplifier Receiver Moduled for Next Generation Optical Front-end System”, IEEE J.

Lightwave Technology, 20, pp. 2229-2238(2002).

5. A.K. Dutta, Nibir K. Dhar, Priyalal S. Wijewarnasuriya and M. Saif Islam, "Novel Multicolor Image Sensors for Bio-Chemical, Bio-Medical, and Security Applications", Proc. Of SPIE Vol. 6008, 600812, (2005).

6. K. Taguchi, "P-I-N Photodiodes" Chapter 8, WDM Technologies: Active Optical Components (A. K. Dutta et. al. eds.), pp. 317-377, Academic Press, Boston, 2002.

7. Goldberg Yu. A. and N.M. Schmidt, "Gallium Indium Arsenide" in Handbook Series on Semiconductor Parameters (M. Levinshtein, S. Rumyantsev and M. Shur, ed.), vol. 2, pp. 62-88, World Scientific, London, 1999.

8. Hamamatsu, Optoelectronics Catalog, 2005.

KEYWORDS: Broadband, Detectors, UV, Visible, Infrared, multispectral, filters.

SB091-006 TITLE: Nanoengineered LWIR Bolometers

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Develop a new technology for bolometers that is low cost, CMOS-foundry compatible, multispectral and that enables higher sensitivity.

DESCRIPTION: Several emerging DoD missions require multispectral and/or polarimetric LWIR surveillance from lightweight platforms. Examples include the imaging of chemical plumes from micro-UAVs. On such lightweight platforms, it is imperative to use an uncooled LWIR camera system, which generally limits the choice of the focal plane array (FPA) to one based on the bolometer approach. However, current State of Art microbolometer arrays do not afford a multispectral/polarimetric ability, and they provide for lower sensitivity, and a slower response time compared to FPAs based on cooled HgCdTe photodiodes. Thus, the DoD has a strong interest in a new bolometer technology that affords multispectral/polarimetric ability, and that also provides for a higher sensitivity (D*) compared to conventional bolometers. Concomitant with this need, several interesting new materials, with interesting properties have been developed by nanoengineering two dissimilar materials (e.g., a metal nanoparticle array in a dielectric matrix) at a length scale of around 10 nm. When engineered at these length scales, the new metamaterial demonstrates interesting mechanical, optical, electrical, and thermal properties. It should be possible to expand the bolometer trade space, and to exploit the expanded trade space with enhanced bolometer functionalities.

This solicitation seeks a radically new bolometer designed around interesting new properties afforded by nanoengineering.

PHASE I: Demonstrate, via relevant models and a prototype proof of concept demonstration, the feasibility of the LWIR bolometer array based on emerging nanotechnologies. As part of the final report, plans for Phase II will be proposed.

PHASE II: Extend the demonstration to a larger array of bolometers (at least 256 x 256), and characterize the performance via appropriate metrics (NEDT, Modulation transfer function, response time etc.). Required Phase II deliverables will include a prototype 256x256 array with complete characterization report.

PHASE III DUAL USE APPLICATIONS: Several units of bolometer array based on emerging nanotechnologies will be manufactured and a series of qualification tests will be performed to validate the design and its performance. This technology has broad applications in military and various commercial sectors. Low cost, multispectral/polarimetric, and room temperature FPAs should find dual use in several non-DoD applications. Examples include nighttime imaging from automobiles, surveillance cameras, home insulation etc.

REFERENCES:
1. D. A. Boyd, L. Greengard, M. Brongersma, M. Y. El-Naggar, D. G. Goodwin "Plasmon-Assisted Chemical Vapor Deposition" Nano Letters, 2006, 6(11), 2592-2597.

2. Gang Chen Nanoscale Energy Transport and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons (Mit-Pappalardo Series in Mechanical Engineering) Oxford University Press, USA (March 3, 2005) ISBN-10: 019515942X.

3. P. L. Richards "Bolometers for IR and millimeter waves" J. Applied Physics, 1994, 76(1), 1.

KEYWORDS: Nanobolometer, bolometer, LWIR.

SB091-007 TITLE: Integrated Low Jitter Mode Locked Lasers

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

OBJECTIVE: Design, develop, fabricate and validate hardware that provides a low cost, integrated mode locked laser for microwave source, sampling, and down conversion. While mode locked lasers with pulse repetition rates in the range of 8-12 GHz and timing jitter less than 50 fs are attainable with current techniques, a monolithically integrated approach is novel and offers significant advantages in size and cost.

DESCRIPTION: One of the next microwave photonic system applications is high-speed, high-resolution, electro-optic signal processing of microwave/mm-wave signals. The design and demonstration of innovative high dynamic range, broadband digital receiver systems based on optical analog-to-digital converter (ADC) technology is of interest. These ADCs require ultrashort-pulsed optical sources with extremely low timing jitter and low noise, and offer the potential for high dynamic range digitization and broad unambiguous frequency coverage. A variety of high performance signal processing is possible with this approach[1]. These sources may also have applications as wavelength division multiplexed sources integrated with arrays of modulators[2] for very high capacity communications. Recently, a number of techniques have been demonstrated[3] that allow short pulse generation with extremely low timing jitter, under 200 fs. This level of performance has not been achievable with electronic pulse sources. Present optical mode locked laser technology utilizes a large number of optical elements. Recent developments in making photonic integrated circuits[4] suggest that integration of the elements is possible, enabling the demonstration of compact, high performance short pulses sources at low cost. Further, the recent advances in lowering waveguide losses together with the lower losses resulting from monolithic integration should allow the demonstration of lower levels of intensity and phase noise, resulting in improved levels of timing jitter. The goal of this program is to demonstrate integrated mode locked lasers and to investigate the inclusion of novel pulse shaping techniques to achieve stable mode locking with under 50 fs of jitter. Repetition rates in the range of 8-12 GHz are of interest.

PHASE I: Prepare a Phase I feasibility study to develop prototypes of a low cost, integrated mode locked laser for sampling and down conversion. Design an integrated mode locked laser for use in optical samplers, photonic ADCs and optical receivers. Investigate designs for minimum pulsewidth and jitter. Optimize the design for 8-12 GHz operation. As part of the final report, plans for Phase II are to be proposed.

PHASE II: The design from Phase I will be finalized. A critical design review will be performed to finalize the design and a prototype unit will be manufactured and tested. Fabricated devices will be characterized for coupling loss to optical fiber, pulsewidth, jitter, temperature dependence, intensity noise and maximum output power.

PHASE III DUAL USE APPLICATIONS: In addition to their use in DoD applications, integrated transmitters would be of interest for low cost computer interconnections and telecommunication applications. Multiple units of the design will be fabricated and a series of qualification tests will be performed to validate the design and its performance. Commercial and military ADCs could benefit from these MLLs.

REFERENCES:
1. "Optical Frequency Combs from Semiconductor Lasers and Applications in Ultra-wideband Signal Processing and Communication," P. J. Delfyett, S. Gee, M. Choi, H. Izadpanah, W. Lee, S. Ozharar, F. Quinlan, T. Yilmaz, IEEE Journal of Lightwave Technology, Vol. 24, No. 7, pp. 2701-2719, (2006).

2. "Cascaded silicon micro-ring modulators for WDM optical interconnection," Q. Xu, B. Schmidt, J. Shakya, and M. Lipson, Optics Express, Vol. 14, Issue 20, pp. 9431-9435.

3. “Greater than 20 db supermode noise suppression and timing jitter reduction via CW injection of a harmonically mode-locked laser”, F. Quinlan, S. Gee, S. Ozharar, P.J. Delfyett, IEEE Photon. Tech. Lett, Vol. 19. No. 16, 1221-1223 (2007).

4. “Mode-locked silicon evanescent lasers”, B. R. Koch, A. W. Fang, O. Cohen, and J. E. Bowers, Optics Express 15, 11225 (2007).

KEYWORDS: Integrated photonics, Silicon photonics, analog links, phased array radars.

SB091-008 TITLE: Design and Fabrication Techniques for 3-Dimensional Integrated Circuits

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: Develop the capability to design for, and/or fabricate, greater than or equal to 3 stacked wafer or die “tiers” to achieve a significant increase in I/O bandwidth capability between several specialized circuit tiers which may contain processors, circuits, memory, etc.

DESCRIPTION: The ability to integrate circuits in the 3rd dimension will be a key enabler for variety of DoD applications, particularly those requiring ultra-high memory bandwidth and low latencies such as high performance computing or embedded processing where performance, size and power benefits of using the 3rd dimension can be leveraged. True 3-D circuit integration (as opposed to 3D packaging or multi-chip modules) integrates multiple wafer, or die, tiers into a single circuit, which provides greater bandwidth and lower power by eliminating much of the off-chip signaling normally done in 2D IC’s. There has been success, to date, in die-level stacking of edge connected tiers and with through-silicon interconnection of 2 tiers with vias sizes of 1-10 micrometers, but there has been no evidence of achieving through-silicon integration of 3 or more layers near these dimensions. Furthermore, circuit designers have limited CAD and simulation tools with which to explore and design in a 3D topology. CAD technology must also be developed in the areas of 3D layout and routing tools, taking into account exclusion areas (for the vias) and inter-layer timing delays, as well as electro-thermal management and 3D design space exploration for achieving optimal 3D implementations. To date, the state-of-the art 2-tier systems have avoided thermal issues by putting the active logic on a single layer and using the second layer for memory or passives. It would be highly desirable to move beyond this constraint and be able to perform the appropriate analysis to build active logic on any layer for optimum system performance. Design approaches exploiting 3D topology for enabling significant improvements in power dissipation with respect to 2D designs are also of strong interest for this solicitation. This SBIR seeks to develop both the advanced semiconducting process capabilities and/or the design tool technologies necessary for the 3D integration of wafers or die.

PHASE I: Demonstrate feasibility of proposed 3D design tool or tier integration/fabrication technology. The 3D fabrication technology should be capable of scaling down to vias of the order of ≤Ü 10 micrometers in size with pitch between the vias of the order of ≤Ü 25 micrometers. Determine using analysis, simulation and/or basic experiments the expected performance focusing on data bandwidth and latency between layers, providing an application example which would benefit from the improvement over a comparable 2D implementation. An alternative analysis might be performed highlighting the reduced power consumption of the 3D design with respect to an equivalent 2D implementation. Describe a prototype stacked chip system that would demonstrate 3D circuit benefits. Technology must be extendable to multiple greater than or equal to 3 tiers of active circuitry. Resulting system should show an order of magnitude improvement in power-delay-area product.

PHASE II: Design an application using new 3D CAD tool or fabricate using tier integration methodology, a 3D stacked prototype chip system as described during Phase I. Provide measurements and analysis proving improved performance and/or lower power of the circuit wrt a 2D implementation of the same.

PHASE III Dual-Use Applications: Dual use applications include sensors, mobile communications, digital signal processors, embedded and high performance computing.

REFERENCES:
1. “Three-Dimensional Integrated Circuits: Performance, Design Methodology, and CAD Tools”, Das, Chandrakasan and Reif, ISVLSI "03: Proceedings of the IEEE Computer Society Annual Symposium on VLSI (ISVLSI "03), IEEE Computer Society, 2003.

2. “Three-Dimensional Integrated Circuits” Topol, La Tulipe, Jr., Shi, Frank, Bernstein, Steen, Kumar, Singco, Young, Guarini and, Ieong, IBM J. Res. Dev., 50, 4/5, IBM Corp, 2006.

3. “Three-dimensional place and route for FPGAs”, Ababei, C.; Mogal, H.; Bazargan, K, IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, Vol 25 No. 6, June 2006, 1132 ¨C 1140.

KEYWORDS: Integrated Circuits, Three-Dimensional Integrated Circuits, Bandwidth, Processing, Design, CAD Tools, Wafer.

SB091-009 TITLE: High-Resolution Imaging of Large Field-of-View Scenes

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Design and demonstrate low size, weight, and power camera hardware for uniform, high-resolution, video-rate imaging of large field-of-view, dynamic scenes, with broad brightness ranges, from one viewing point, offering easy trade-off between cost and image quality.

DESCRIPTION: Standard video cameras acquire high-resolution video over a narrow field of view. To image large visual fields with conventional cameras, imaging parameters, such as viewing direction, need to be varied to relocate the narrow visual field across the scene. Innovative camera designs are needed to achieve the high resolution everywhere, so they provide global views as well as capture local details. The desired design would exploit physical (real-time) processes to acquire seamless, high-acuity, real-time video over a large, contiguous visual field, with high geometric fidelity, common viewpoint, no blind spots, and high color and brightness sensitivity in all directions. Currently available designs, including those using a single sensor with a large field of view, and those using a cluster of multiple sensors without a common viewpoint generally do not meet these needs. For example, current ultra-wide field of view video systems that offer the requisite resolution do so with camera arrays that are neither compact nor lightweight. The required design should allow a cost-performance tradeoff by giving user the option of reducing unit costs in exchange for reduced field of view or reduced image quality. Low cost and compactness are major considerations for acceptability.

DARPA seeks a compact, lightweight video camera system that offers extreme angular coverage, such as a hemispherical view (180 degree horizontal x 180 degree vertical) or a quarter sphere view (90 degree H x 90 degree V), while maintaining high resolution, such as 0.4 mrad/pixel or better (1.25 cycles/mrad or better) over the entire field of view without the need to pan the camera to cover the visual field. The video camera system should be free of imagery common artifacts such as skew and smear. The system should be robust, with low/no maintenance operation and low power consumption. The video stream should be no less than 25 frames per second (non-interlaced) and should be capable of performing on-board processing for sensitivity adjustment, noise correction and dynamic equalization at operational video rates. The camera system should meet the following size, weight and power requirements, inclusive of all optics and electronics necessary to produce the desired video output, but exclusive of external packages necessary for environmental protection, electrical connectors for power, control, and video signals, and electronics necessary for power supply and/or power conditioning:

– The camera system shall fit within a simple form factor not exceeding 2000 cubic centimeters in volume..
– The camera system shall weigh no more than 0.5 kg.
– The camera system shall consume no more than 20 watts electrical power, including buffers or drivers necessary for either digital output or conventional video output.

PHASE I: Design of the complete video camera system to meet or exceed the above goals. If possible, the design should be validated using tests to determine the technical feasibility of critical subsystem elements. Identify any risks with the approach and develop risk mitigation for the production of a prototype camera system.

PHASE II: Finalize and validate the design from Phase I. Produce a prototype video camera system hardware for the entire camera and associated software and interface. Determine the reliability and limitations of the imaging system. Demonstrate a method to store, review, and manipulate the video-rate imagery.

PHASE III: Demonstrate robust, functional camera. Demonstrate the camera in military applications such as battlefield visualization, situational awareness, navigation, perimeter guarding, and general surveillance and monitoring. Make the camera operational, by deploying it in defense systems. Establish commercial need. Determine feasibility of volume production and deployment. Demonstrate specific commercial applications.

REFERENCES:

1. http://www.pelco.com/

2. H. Hua, N. Ahuja, and C. Gao. "Design analysis of a high resolution panoramic camera using conventional imagers and a mirror-pyramid," in IEEE Transactions on Pattern Analysis and Machine Intelligence, 29(2), 356-61, February 2007.

3. K. Miyamoto, "Fish eye lens", Journal of Optical Society of America, August 1964, 64:pp.1060-1061.

4. V. Nalwa, "A true omnidirectional viewer", Technical report, Bell Laboratories, 1996.

5. S. K. Nayar, "Catadioptric omnidirectional camera", in Conf. on Computer Vision and Pattern Recognition, 1997, pp. 482-488.

6. K. Yamazawa, Y. Yagi, and M. Yachida, "Omnidirectional imaging with hyperboloidal projection", Intl. Conf. on Intelligent Robots and Systems, July 1993, pp 1029-1034.

7. http://www.ptgrey.com/products/ladybug2

8. R. Athale, D. M. Healy, D. J. Brady, and M. A. Neifeld, "Reinventing the Camera," Optics & Photonics News, 2008, Vol 19, pp. 32-37 http://www.opticsinfobase.org/abstract.cfm?URI=OPN-19-3-32

9. R. Reulke, U. Knauer "Panoramic Photogrammetry Workshop" Proceedings of the ISPRS working group V/5, February 2005. http://www2.informatik.hu-berlin.de/sv/pr/PanoramicPhotogrammetryWorkshop2005/Proceedings.htm

KEYWORDS: Large field-of-view, Video rate, High resolution, Video camera.

SB091-010 TITLE: <u>Panoramic Helmet-Mounted Display and Processing</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a prototype of a panoramic, wide field of view helmet-mounted display, which presents the user with information from a minimum 90 degree horizontal field of view (FOV) with a goal of 120 degree horizontal and 40 to 50 degree vertical field of view, including signal processing adaptable to scene content.

DESCRIPTION: Significant advances have taken place in the development of large format imaging sensors, with mega-pixel sensors available in several spectral bands. These large sensors, which cover a wide field of view, fulfill the requirements for many applications, but are especially important in helmet-mounted systems for both ground and pilotage applications. However, the display technology essential to presenting the large amount of information generated by the sensor lags considerably behind the sensor technology. Currently, display technology is limited in field of view, and does not have the integral signal processing to match the capability of large format sensors and to adapt the information to meet user needs.

The need to efficiently display a large amount of information to the user is crucial to mission success. Information must be available to detect threats at the periphery of vision, to discern details as needed by the situation, and to perform intricate tasks. Meeting all of these requirements simultaneously requires a significant leap-forward in display and signal processing technology. The display must meld the requirement for full panoramic field of view with the need for an adaptable, high resolution instantaneous field of view.

The display must provide high image quality in a light weight package, with the ergonomics required for user acceptance, such as the center of mass optimized for head-mounted applications. The display format must be extended beyond the current state of the art, leading to innovative concepts in Mega-pixel displays with a high visual acuity in the central region and lower resolution in the periphery of the display. Novel signal processing and image reconstruction techniques must be applied to present the user with the essential scene content. The goal is to develop innovative sampling techniques that require only a small percentage of the data to reconstruct high quality scene information. These techniques have been demonstrated in radar and acoustic signal processing, but not implemented in helmet mounted displays. Although signal processing techniques have been demonstrated, there is considerable risk in the implementation of these techniques in display systems. However, the pay-off is large, enabling the user to grasp the large amount of information generated in a panoramic scene.

Emerging technologies in compressive sampling, where the information rate may be much smaller than the bandwidth, enables the presentation of only the essential information without loss of scene content. These new techniques can be integrated with wide field of view display components to present information from a wide field of view at minimum power, essential to helmet-mounted systems. The integrated display/processor not only presents information to the user, but also integrates functions to reduce workload, increase the situational awareness and enhance the ability to perform essential tasks.

In military display applications, a wide field of view combined with the flexibility to perform multiple functions, and elimination of display artifacts that detract from image quality, are essential to user acceptance of the technology. The display technology must have a fast response time so that the image is free of artifacts due to target movement or head-movement. Frame update rate of at least 60 Hz minimizes image artifacts and blurring. An innovative feature of the display technology should be the flexibility to integrate inputs from external sources as well as the ability to export selected areas to other sensor systems.

The physical configuration of the display must conform to the user with an unobtrusive format, conformal with the helmet, fitting similar to a visor, and with the display configured with optimum binocular overlap to provide high resolution and a contiguous view of displayed information. The brightness should be sufficient to present high contrast information, even in high light ambient environments. Also, the physical configuration must be such that illumination from the display is visible only to the user and keeps the system convert.

Applications include aviation and ground applications. The signal processing functions should be adaptable, allowing the display processing system to be used in multiple environments.

PHASE I: Define issues associated with the development of a novel concept in wide field of view display technology for helmet mounted applications; design the micro-system concept for panoramic helmet mounted display that includes adaptable compressive sampling to present essential scene content to the user. Perform simulations to demonstrate significant features of the display and advantages in military ground and airborne applications. Plans for Phase II will be proposed, including display component requirements and signal processing design.

PHASE II: Demonstrate the wide field of view display concept demonstrator with panoramic field of view, showing central region visual acuity approaching 20/20, with a minimum of 8 bits per pixel with a goal of 16 bits per pixel; show viability of the signal processing approach, display component technology, and the integration of signal processing with the display.

PHASE III: DUAL USE APPLICATIONS: Multiple applications for wide field of view display technology are in aircraft simulators and training systems. The display will present information from a wide field of view and provide a realistic view of the scene, while the integral signal processing will maintain and enhance the details in the scene necessary to perform intricate tasks.

REFERENCES:
1. Patterson R., Pierce B.J., Winterbottom M. C., "Perceptual Issues in the use of Head-Mounted Visual Displays" Journal of the Human Factors and Ergonomics Society, Vol 48 No. 3, 2006. pp 555-573.

2. Brickner M.S., "Helicopter Flights with Night-Vision Goggles-Human Factors Aspect" NASA Technical Memorandum 101039, March 1989.

3. E. J. Candès and M. Wakin. An introduction to compressive sampling. IEEE Signal Processing Magazine, March 2008 21-30. (pdf)

4. E. J. Candès. Compressive sampling. Proceedings of the International Congress of Mathematicians, Madrid, Spain, 2006. (pdf)

5. Compressive Optical MONTAGE Photography David J. Bradya, Michael Feldmanb, Nikos Pitsianisa, J. P. Guoa, Andrew Portnoya, Michael Fiddyc aFitzpatrick Center, Box 90291, Pratt School of Engineering, Duke University, Durham, NC 27708.
Digital Optics Corporation, 9815 David Taylor Drive, Charlotte, NC 28262.
Center for Optoelectronics and Optical Communications, University of North Carolina Charlotte, 9201 University City Blvd. Charlotte, NC 28223.

KEYWORDS: Helmet-mounted displays; wide field of view; visual perception.

SB091-011 TITLE: Submarine Pressure Hull Tomography

TECHNOLOGY AREAS: Ground/Sea Vehicles

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Investigate and validate use of non acoustic tomography for non-destructive evaluation of the structural integrity of base metals and elements of submarine hull structures without requiring removal of special hull treatments or external structures.

DESCRIPTION: Submarine maintenance requirements include precise inspection and survey requirements. Typical non-destructive inspection techniques include ultrasonic, magnetic particle, dye penetrant and radiographic techniques. Application of these techniques requires specialized training, tools and techniques. Recent advances in medical and industrial tomography suggest an opportunity for new, rapid non-invasive inspection and evaluation technologies. This effort seeks to develop and apply innovative tomographic approaches to submarine hull inspection.

PHASE I: Determine technical feasibility for real-time or post measurement analysis of tomographic evaluation of submarine pressure hulls through a hull treatment. Phase I deliverables will include analysis of resolution and include a detailed analysis of predicted performance considering spatial resolution (minimum resolvable feature size), registration, and error analysis. As part of the final report, plans for Phase II will be proposed.

PHASE II: Phase I design will be finalized and presented during a critical design review. Construct and demonstrate the operation of a prototype tomographic assessment system in a series of appropriate developmental and performance validation tests. Culminate Phase 2 with scaled testing in air and salt water immersion substantiating system performance in terms of spatial resolution, registration, and error analysis, and compare results with a dye penetrant test of the same test sample. This device should be at or above Technology Readiness Level 5 (Component and/or breadboard validation in relevant environment) at the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Phase III military applications are submarine and submerged structure non-destructive evaluation. Potential commercial applications include corrosion and maintenance analysis of ship tankage and hull structures and commercial underwater piping and structures.

REFERENCES:
1. S9086-CH-STM-010/CH-074R4, Naval Ships' Technical Manual Chapter 074 - Volume 1 Welding and Allied Processes.

2. Lombardini, F. Differential Tomography: A New Framework for SAR Interferometry. IEEE Transactions On Geoscience And Remote Sensing, Vol. 43, No. 1, January 2005.

3. Cui, Z. et al. A Specific Data Acquisition Scheme for Electrical Tomography. IEEE International Instrumentation and Measurement Technology Conference, May 2008.

6: Additional information provided by TPOC in response to FAQs. Includes 41 sets of Q&A.

KEYWORDS: non-destructive evaluation, tomography, submarine hull inspection.

SB091-012 TITLE: Robust Distributed GPS Apertures

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate algorithms and techniques to achieve robust GPS positioning in a sensor network using a distributed GPS aperture to overcome jamming, multipath, and signal blockage conditions.

DESCRIPTION: The DoD is heavily dependent on the Global Positioning System (GPS) for worldwide military operations. The GPS signal is subject to a variety of potential degradations, such as path loss (e.g., foliated or indoor environments), multipath (e.g., urban canyon or in-building), and interference (intentional or unintentional—the weak GPS signal is more vulnerable than other radio links such as the network). There are also a number of situations in which a group of GPS users may operate together in a denied or degraded GPS environment. Using the traditional GPS receiver approach, individual or all users may be denied the ability to navigate in such an environment, even though each user may be intermittently receiving useful satellite signal information. Collectively, the network of GPS users may be able to receive sufficient satellite signals, augmented by intra-network ranging measurements, in order to form a joint position determination. In addition, such a network of receivers represents a spatially diverse distributed aperture which may be capable of obtaining gain and interference mitigation. Additional mitigation is possible if one or more nodes samples the environment with an antenna array.

This topic will address distributed GPS position and navigation techniques that mitigate denied or degraded tactical RF environments. Algorithms and techniques should be developed that demonstrate the ability of a networked group of GPS receivers to operate under adverse conditions in which an individual receiver would be impaired.

PHASE I: Develop algorithms, techniques, and a system concept for networked and distributed GPS apertures and processing which overcomes adverse RF environments to allow positioning and navigation. Demonstrate feasibility and quantify performance using analysis and simulations.

PHASE II: Develop a sub-scale demonstration of a robust distributed GPS aperture, demonstrating the ability of a group of nodes to successfully navigate under denied or degraded conditions, as compared to a single COTS reference receiver whose performance is impaired. Evaluate the feasibility of transitioning these capabilities into realistic tactical scenarios, including planned DoD GPS user equipment upgrade spirals, and network integration with military radio terminals (e.g., JTRS).

PHASE III DUAL USE APPLICATIONS: This technology, if realized, would be of obvious immediate benefit to both DoD and commercial GPS users operating in challenging RF environments. DoD applications include tactical squads operating under foliage, indoors, or in urban conditions, as well as similarly challenged unattended sensor networks. Commercial applications include personal handheld navigation (e.g., embedded in cell phones) and mobile vehicular users (e.g., automobile, fleet/trucking) operating in obstructed urban or rural environments. Solutions to RF interference apply to both DoD and commercial applications.

REFERENCES:
1. Allison N. Kealy, Maria Tsakiri & Mike Stewart (1999). Land vehicle Navigation in the Urban Canyon-A Kalman Filter Solution using Integrated GPS, GLONASS and Dead Reckoning. ION GPS'99, 14-17 September 1999, Nashville,TN. Pp509-518.

2. Hofmann-Wellenhof B. et al. (2004). Global Positioning System: Theory and Practice.

3. Major West Kasper, May 1 2004. GPS Vulnerability Testing. GPS World. http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=95325.

KEYWORDS: Global Positioning System, Urban Environment, Distributed Apertures, GPS Degradation, Digital Signal Processing Techniques, Interference Cancellation, Differential GPS.

SB091-013 TITLE: High Energy Micro Rocket Stages for Tactical & Space Applications

TECHNOLOGY AREAS: Air Platform, Space Platforms, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a Phase I feasibility study to design, manufacture, and test a micro-scale rocket-powered stage or its components, followed by demonstrating a small, very high energy (i.e., velocity change) liquid stage enabling potential applications including small tactical missiles, global reach boost glide aircraft, spacecraft, upper stages, etc.

DESCRIPTION: Many established aerospace and emerging entrepreneurial companies are developing new rocket stage technologies. The goal of this solicitation is to leverage these investments to enable small, high performance rocket stages with a high velocity or payload capability. Technological trends facilitating small stages include an ongoing computer/software revolution enabling affordable design, integration and test; micro-miniaturization of electronics and mechanical actuators; high strength to weight composites and nano-materials; light weight structures and thermal protection supporting ballistic or high lift/drag glide; high thrust/weight very small rocket engines and turbo-machinery; and natural occurring or designer fuel and oxidizers supporting high density impulse liquid propellants.

The offeror must demonstrate a clear understanding of the system applications of the stage and the supporting technologies. Potential system applications include small tactical missiles for on UAV's, helicopter and Close Air Support missions; satellite and upper stages; and future boost glide or ballistic air vehicle systems. Similarly, a clear understanding of the technology applications is also essential. For example, high density impulse propellants such as peroxide and JP-10 have nearly 3X the thrust per cubic foot of propellant flow versus more energetic propellants like oxygen/hydrogen, lending themselves to much smaller stages and turbo machinery with very high propellant mass fractions. Designer variants of such propellants could potentially be hypergolic, have higher density impulse, longer term storage capabilities, be useful as a monopropellant and could potentially be safer than many of today's carcinogenic and dangerous propellants; again lending themselves to both smaller stages and as potential replacements to today's storable propellants. Offeror's are expected to demonstrate a clear understanding of both innovative system and component applications and their advantages to various military and commercial needs. Offeror's may seek to design and fabricate an entire stage or only critical components.

PHASE I: Identify potential system level and technology applications of the proposed innovation. Although multiple applications are encouraged, to help assess the military utility at least one of the following reference missions should be evaluated: 1) a very small, agile tactical missile supporting UAV and/or Close Air Support missions able to carry a 10-lb. munition with an ideal velocity change of 10,000 fps threshold to 15,000 fps objective, or 2) a small scalable stage demonstration for future satellite, upper stage and boost glide or ballistic air vehicle applications able to carry 100 lbs of payload with an ideal velocity change of 20,000 fps threshold to 25,000 fps objective, or 3) a safe, storable and affordable alternative to today's carcinogenic propellants such as hydrazine, unsymmetrical dimethylhydrazine and red fuming nitric acid with at least equivalent impulse density and specific impulse.

Using the above concepts or an alternative based on the offeror's analysis, develop a specific system design and identify the performance goals, technical feasibility, and innovative enabling technologies and alternatives. The design should include a detailed phase II development plan for the technology addressing cost, schedule, performance and risk reduction. Technology and hardware risk reduction demonstrations at the component and/or system level should be identified, along with manufacturing and testing required to carry the program into Phase II and III. Hardware risk reduction during Phase I is encouraged although not required. As a minimum the Phase I deliverables will include system level applications, a system design and a Phase II development plan.

PHASE II: Finalize the phase I design, then develop, demonstrate and validate the system design, critical hardware components and/or enabling technologies. Design, construct, and demonstrate the experimental hardware or component prototypes developed in Phase I. The Phase II demonstration should advance the state of the art to between Technology Readiness Level 4 and 6. Required phase II deliverables will include the experimental prototype hardware and a final report including design data, manufacturing and test plan, test data, updated future applications, etc.

PHASE III DUAL USE APPLICATIONS: The offeror will identify military and commercial applications of the proposed innovative technology(s). Technology transition and/or commercialization opportunities will be identified along with the most likely path for transition from SBIR research to an operational capability. The path should include one or more commercial applications, as well as specific military applications and operational customers.

REFERENCES:
1. Modern Engineering For Design of Liquid Propellant Rocket Engines, Dieter Huzel, David Huang, Harry Arbit, 1992. (Density Impulse defined, pg 19).

2. http://www.darpa.mil/ucar/programs/Falcon.htm (DARPA Falcon program HTV-2 boost glide technology demonstrator).

3. http://www.darpa.mil/sto/chembio/biofuels.html (DARPA bio fuels program, designer fuels).

KEYWORDS: Point to point, ballistic, transport, suborbital, flight, VTOL, rocket, micro, tactical, space, airlift, boost glide and propulsion.

SB091-014 TITLE: Personal Air Vehicle Technology

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Define new and innovative technology components that enable building a vehicle which can either be used as a 2-4 person ground transport that can both drive on roads or be changed into a flying craft with vertical take off capability. Identify selected technologies providing propulsion, morphing wings, and/or flight controls that provide core elements for this multi-person vehicle. Identify issues to be resolved via trade studies and define demonstrations establishing the feasibility of the identified core component technologies.

DESCRIPTION: A personal air vehicle that could transport 2 to 4 personnel either by driving on the ground or by flying would be suitable for many military scouting and personnel transport missions. This personal air vehicle should also have a vertical take-off capability that is not restricted to prepared surfaces for the most military utility. Desired personal air vehicle characteristics would be the ability to fly for 2 hours carrying a 2 to 4-person payload on one tank of fuel and can also safely travel of roads. The vehicle must be no wider than 8.5 feet and no longer than 24 feet, and no higher than 7 feet when in the road configuration. Vehicle control must support manually driving the vehicle on the ground and fully automated flight with manual flight control inputs that can override the fully automatic system. The challenge is to define the major components of such a vehicle that would be suitable for military scouting and personnel transport missions, yet are small enough, inexpensive enough, and easy enough to operate that it can be widely used. To achieve this it will be necessary to explore new and innovative technologies in one or more of the following areas:

- Propulsion concepts that include vertical take off and vertical landing, optimized disk loading for the combined fly/drive mission, size, weight, and power suitable for a road drivable vehicle, efficient power plant and energy management combined with low specific fuel consumption, and installation considerations related to safety, vehicle controllability, and passenger/payload carrying on a vehicle. The optimized disk loading should allow safe take off/landing at unprepared sites.

- Morphing wing/surfaces considerations including safe and rapid deployment and retraction, rugged construction, and ease of operation for a vehicle that can drive at up to 60 mph and fly at up to 150 mph.

- Flight control considerations include human interfaces to autopilot, flight director, and/or auto-navigation systems, automated navigation/ positioning, automated sensors, automated fight planning and de-confliction with other users of the airspace. Size, weight, and power must be paramount as well as redundancy and reliability suitable for human passengers.

PHASE I: Prepare an initial personal air vehicle concept design that supports the modeling of selected key elements (propulsion, morphing wing/surfaces, flight control). Develop detailed analysis of predicted performance for the selected key technical elements (propulsion, morphing wing/surfaces, and flight control). Perform modeling and simulation of the selected key technical elements, and define and develop key component technical milestones. Phase I deliverables will include for the selected key technologies suitable simulations, and modeling results and the development plans.

PHASE II: Construct and demonstrate the operation of prototypes of the key component technologies (propulsion, morphing wing/surfaces and/or flight control). Establish performance parameters of these key technologies through experiments using the prototypes.

PHASE III DUAL USE APPLICATIONS: Develop, demonstrate, and validate a full scale flying/driving prototype of the personal air vehicle. The prototype personal air vehicle should be able to transport 2 to 4 personnel either by driving on the ground or by flying. This personal air vehicle should also have a vertical take-off capability that is not restricted to prepared surfaces for the most military utility. The prototype personal air vehicle is to be suitable for many military scouting and personnel transport missions (urban scouting, casualty evacuation, inserting SOF teams) or commercial counterparts and to be robust enough to support initial military user evaluation of its potential utility.

REFERENCES:
1. http://www.faa.gov/aircraft/gen_av/light_sport/

2. U.S. Department of Transportation Federal Aviation Administration Order 8130.2F, CHG 3 National Policy Effective Date: April 18, 2007 SUBJ: Airworthiness Certification of Aircraft and Related Products.

3. http://rgl.faa.gov/regulatory_and_guidance_library/rgorders.nsf/0/1BA6EE60E8779BD7862572C90063C0AC?OpenDocument

4. Federal Aviation Administration Web site: http://en.wikipedia.org/wiki/Personal_Air_Vehicle

5. Federal Aviation Administration Web site: http://www.faa.gov/aircraft/gen_av/light_sport/

6. Wikipedia org: http://en.wikipedia.org/wiki/Moller_Skycar

7. Urban Aeronautics Web site http://www.urbanaero.com/Urban_Main.htm

8. Paul-V Web site http://www.pal-v.com/

9. The Register Web site: http://www.theregister.co.uk/2007/10/10/transition_flying_car_quite_realistic/

KEYWORDS: Personal Air Vehicle, Air Platform, Flying Car.