DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY2009.B STTR 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 Technology Transfer (STTR) Program rests with the Innovative Research Office.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Attention: DIRO/SBIR/STTR
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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 STTR 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 upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3 of the STTR 9.B solicitation. Phase II proposals will be evaluated in accordance with the evaluation criteria provided in Section 4.3. Due to limited funding, DARPA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

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 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" are 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 STTR 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 STTR 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 STTR company has identified to support transition activities. Also include key proposed milestones anticipated during Phase I, II or beyond Phase II that include, but are not limited to: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.

4.5 STTR 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 STTR funding if the performer can match the additional STTR funds with non-STTR 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/STTR 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 STTR 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 STTR Company's Phase III technology development activities. Thus, identification of potential funding sources will be primarily focused on enabling the STTR 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 STTR 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 STTR Company shall be carried out at no cost to The Foundation or DARPA and are not billable to any STTR contract. The STTR 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 STTR 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 STTR Company will develop appropriate company profiles, briefings and other types of informational materials to support discussions and briefings. STTR 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/STTR Web site. STTR 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/STTR Web site. The 2007 DARPA SBIR/STTR 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 STTR companies, and will help develop and implement process improvements to increase transition success for DARPA STTR funded companies. Transition outreach includes panel presentation and one-on-one meetings at selective STTR conferences. Additional transition–related documentation and links will be available upon request and via the SBIR/STTR Web site in the future. All active DARPA STTR 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.
- Companies are strongly encouraged to pursue implementing a government acceptable cost accounting system during the Phase I project to avoid delay in receiving a Phase II award. Visit www.dcaa.mil and download the “Information for Contractors” guide for more information.

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.
- DARPA may choose to award a Firm Fixed Price Phase II contract on a case-by-case basis. However, companies are advised to continue pursuit of implementation of a government acceptable cost accounting system in order to facilitate their eligibility for future government 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.

5.2.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. Requests for clarification to information provided in the debriefing summary must be sent via e-mail to sbir@darpa.mil within 15 days of receipt of notification.

DARPA STTR 09B Topic Index

DARPA STTR 09B Topic Descriptions

ST092-001 TITLE: Optimizing Human Memory Formation for Better Decision Making

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a low cost, deployable system that will enhance Warfighter memory and recall of large quantities of information, leading to more effective decision making.

DESCRIPTION: Good decision making depends on quickly and accurately recalling information when it is most needed. Quick and accurate information recall, in turn, depends on effectively consolidating relevant information into memories. With the growing trends in developing information systems that display increasingly greater amounts of data, new technologies are needed that help our Warfighters optimize the neurocognitive processes underlying the storage of information into memory. Traditional memory theory divides this process into two stages: Acquiring the information into working memory; and, Encoding the information into long term memory [1]. Recent findings indicate that memorization and subsequent recall are optimized when these two processes are coordinated in time [10]. To do this effectively however, requires identifying the basic neural markers of these memory processes and using the timing of these markers to correctly phase the presentation of the to-be-remembered information.

Recent advances in learning and memory research indicate that at the neural scale, memory formation depends on interactions between different patterns of nerve cell activity [3] which appear as waves of synchronization [4,5]. Two of the most important frequencies are Gamma and Theta [6,7], both of which are essential for acquiring, encoding and recalling memories [8,9]. Computational models [10] suggest that Gamma waves enable the acquisition of information into working memory, while Theta waves facilitate the subsequent encoding of this information into long term memory [2]. These findings are supported by recent demonstrations that link these frequency signals with cognitive performance on memory tasks [11]. Gamma and Theta, therefore, should provide the timing cues necessary to correctly stage information presentation to optimize the acquisition and encoding of information into memories, leading to more effective and accurate recall.

The results of this effort will be a system that identifies and or induces the onset of Gamma and Theta waves (in real-time) and that uses this information to synchronize the presentation of to-be-remembered information to optimize memory formation. The system will present this information in a manner that facilitates Gamma and Theta generation and synchronization. The system will be lightweight, easy to use and unobtrusive. Success will be assessed in terms of performance metrics that include: 1.) reliably promoting and determining Gamma and Theta onset in over 50% of all trials; 2.) synchronizing information presentation in at least 50% of such trials; 3.) significantly ($p<.05$) increasing the total quantity of information reliably recalled from a given learning session over a minimum of three durations - 24 hours, one week, and one month post exposure.

PHASE I: Prepare a feasibility study for developing a system that will rapidly detect (and techniques to help induce) the appropriate neural states underlying memory formation and use this information to cue information presentation. During the first phase the performer will propose a conceptual device and a preliminary design/architecture, to include descriptions of: sensor technologies, the synchronization methodology and the information presentation approach. A final report will be generated, including system performance metrics and plans for Phase II. Phase II plans should include key component technological milestones and plans for at least one operational test and evaluation using an operational system. Phase I should also include the processing and submission of all required human subjects use protocols.

PHASE II: Develop prototype system based on the preliminary design from Phase I. All appropriate testing will be performed, and a critical review will be performed to finalize the design. Phase II deliverables will include: (1) a working prototype of the technology (2) specification for its development, and (3) test data on its performance collected in one or more operational settings. The prototype must demonstrate significant improvements ($p<.05$) compared to relevant baseline (gold-standard) approaches currently in use.

Target TRL: 6

PHASE III: This technology will have broad application in military as well as commercial settings in which large quantities of information must be quickly and accurately retained for later use in high-risk/high-stress operational settings. The military is reducing the number of personnel involved with weapons platforms and C4ISR systems while increasing the total amount of information that these reduced crews must manipulate. Therefore, systems that help Warfighters effectively process this information are urgently needed. Similar trends are occurring in commercial sectors, where fewer personnel are tasked with processing ever-increasing amounts of information (eg. Air Traffic Control, Commercial Shipping, Manufacturing Facilities, Power Plant Control Systems, Crisis Management/Emergency Management). For the military, this technology will provide a means for ensuring that reduced manpower does not result in reduced readiness and performance. Commercially, this technology will provide a new capability to enable fewer personnel to handle increasingly greater quantities of information across a wide range of domains.

REFERENCES:
1. Wickens, C. D. & Hollands, J. G. (2000). Engineering Psychology and Human Performance (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

2. Jensen, O., Lisman, J.E. (2005). Hippocampal sequence-encoding driven by a cortical multi-item working memory buffer. Trends in Neuroscience. 28(2):67-72.

3. Sederberg, P.B., Kahana, M.J., Howard, M.W., Donner, E.J., Madsen, J.R. (2003). Theta and gamma oscillations during encoding predict subsequent recall. The Journal of Neuroscience. 23(34):10809-10814.

4. Axmacher, N. Mormann, F., Fernandez, G., Elger, C., Fell, J. (2006). Memory formation by neuronal synchronization. Brain Research Reviews. 52:170-182.

5. Singer, W. (1999). Neuronal synchrony: a versatile code for the definition of relations? Neuron. 24:49-65.

6. Kahana, M.J., Seelig, D., Madsen, J.R. (2001). Theta returns. Current opinion in neurobiology. 11:739-744.

7. Kahana, M.J. (2006). The cognitive correlates of human brain oscillations. The Jornal of Neuroscience. 26(6):1669-1672.

8. Osipova, D., Takashima, A., Oostenveld, R., Fernandez, G., Maris, E., Jensen, O. (2006). Theta and gamma oscillations predict encoding and retrieval of declarative memory. The Journal of Neuroscience. 26(28):7523-7531.

9. Mormann, F., Fell, J., Axmacher, N., Weber, B., Lehnertz, K., Elger, C.E., Fernandez, G. (2005). Phase / amplitude reset and theta-gamma interaction in the human medial temporal lobe during a continuous word recognition memory task. Hippocampus. 15:890-900.

10. Lisman, J.E., Idiart, M.A.P. (1995). Storage of 7 ± 2 Short-Term Memories in Oscillatory Subcycles. Science. 267(5203):1512-1515.

11. Logar, V., Beliè, A. Koritnik, B., Brežan, S., Zidar, J., Karba, R., & Matko, D. (2008). Using ANNs to predict a subject’s response based on EEG traces. Neural Networks 21: 7, 881–887.

KEYWORDS: Neurocognitive, Decision Making, Memory, Gamma waves, Theta waves

ST092-002 TITLE: <u>Computational Models of Leadership</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop computational models of command leadership that address the core characteristics of the successful human leader.

DESCRIPTION: Many good descriptions exist of effective leadership including the following. “The Army defines leadership as influencing people by providing purpose, direction, and motivation, while operating to accomplish the mission and improve the organization.” (US Army, 1993) However, despite the utility of such descriptions for human consumption, few computational models of leadership exist to provide direction in simulations or to support leadership functions in mixed-initiative command and control systems. Those models that do exist (see Hazy, 2007) suffer from incomplete and often simplified implementations. For example leadership models may be construed to bias a complex organization toward exploration or exploitation (Hazy, 2004), or they may shift personnel, resources and tasks associated with activities (Carley & Ren, 2001); but no existing implementation is broad or detailed enough to capture the more intangible aspects related to the leader’s ability to understand and take risk, a capacity for self-assessment and self-awareness, the quality of empathy in social contexts, and the skills of effective communication of guidance and intent. Contrastingly successful leaders understand themselves and their own strengths and limitations and can use such knowledge to motivate a social network through personal example. Leaders understand the situation and demands placed upon senior, peer, and junior individuals with whom the leader is associated and act accordingly. Leaders recognize new problems and set goals to solve such problems. Leaders manage goals as fluid objectives that change over time (Cox & Zhang, 2007) and communicate, negotiate, and coordinate with others to achieve results. The challenge of this topic is to develop a comprehensive, tangible theory of command leadership and to design an implementation of such a theory that provides descriptive, predictive, and explanatory power so that actual leadership is better understood and further enhanced.

PHASE I: Provide a theoretical accounting of command leadership that specifies how salient aspects of leadership can be functionally computed. This theory will be analyzed with respect to a specific application environment that represents the effects of leadership upon a social organization. Develop a detailed method for evaluating the theory that includes both qualitative and quantitative measures. Enumerate a set of requirements for a proof of concept to be implemented in Phase II.

PHASE II: Design, implement and test proof of concept prototype for the target application environment as investigated in Phase I. The implementation will test the predictions of the theory through measurements of the evaluation criteria developed in Phase I. Phase II will demonstrate the implementation in applications that illustrate the positive and negative effects of command decisions for autonomous agents. The implementation will also illustrate benefits in a mixed-initiative (human in the loop) decision-support role (this does not require running human subjects). A useful example would be to understand and to generate leadership guidance (e.g., commander’s intent).

PHASE III: This topic has many dual use applications, including the development of improved decision support for human leaders in industrial management and military strategy. In general, the application opportunities are numerous for systems that can support the leadership function. Critical solutions would benefit industry, the government, and the military, and indeed, all large organizations that manage difficult, complex problems.

REFERENCES:
1. The US Army (1993). Army Leadership. Army Regulation 600–100. 17 Sep 1993, signed by Gen Gordon R. Sullivan, Chief of Staff. www.army.mil/usapa/epubs/pdf/r600_100.pdf

2. Carley, K. M., & Ren, Y. (2001). Tradeoffs between performance and adaptability for C3I architectures. In Proceedings of the 2001 Command and Control Research and Technology Symposium. Conference held in Annapolis, Maryland, June, 2001. Evidence Based Research, Vienna, VA. http://www.dodccrp.org/events/6th_ICCRTS/Tracks/Papers/Track2/082_tr2.pdf.

3. Cox, M. T., & Zhang, C. (2007). Mixed-initiative goal manipulation. AI Magazine 28(2): 62-73. http://mcox.org/Papers/CoxZhangAIMag.pdf

4. Hazy, J. K. (2007). Computer Models of Leadership: Foundation for a New Discipline or Meaningless Diversion? The Leadership Quarterly, Special Issue, 391-410.

5. Hazy, J. K. (2004). Leadership in Complex Systems: Meta-Level Information Processing Capabilities that Bias Exploration and Exploitation. In Proceedings of North American Association for Computational Social and

Organizational Science Conference, Pittsburgh, PA. http://casos.isri.cmu.edu/events/conferences/2004/2004_proceedings/Hazy_James1.doc

KEYWORDS: Leadership modeling, Multiagent systems, Social networks, Goal management, Cognitive models.

ST092-003 TITLE: High speed polarization switching laser

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: Develop and fabricate a polarization switching laser source which can be directly modulated with a 3dB frequency of at least 10 GHz. Small Size, Weight and Power (SWaP) is essential for the laser to be used as a source for military applications including man portable short range LADAR. A polarization switching laser is also expected to have significant application optical communications.

DESCRIPTION: Polarization diversity has gained more and more momentum in recent years, resulting in a considerable interest to build a laser source which is capable of high speed polarization switching. An application which is in need of such a device is laser-detection-and-ranging (LADAR). LADAR systems are in widespread use today and vary in their complexity and application. Ranging LADAR is used to determine the range to the target by measuring the time taken for the light to travel to the target and back. When combined with three-dimensional computer modeling, for instance, ranging LADAR will allow UAVs and robotic vehicles to navigate safely through unknown terrain. However, for targets in clutter and partially hidden targets, there are ambiguities in determining which pixels are on target that lead to uncertainties in determining the target's 3-D shape. A promising method for improving the determination of which pixels are on target is to use the polarization components of the reflected light. Utilizing polarization switching capability at the source can lead to considerable improvement of the LADAR data quality.

This new class of device will be critical not only for LADAR, Optical Interconnects, and Free Space Optical communications, but will open up a whole new class of devices and applications which exploit ultra high speed direct modulation of polarization. Other applications include sensing and imaging applications, as well as the possibility of exploiting polarization with wavelength, time and space to perform optical processing functions. Many of these applications are currently not feasible as low cost polarization and/or low cost ultra-high speed array sources are currently not available. In order to have a considerable impact on the applications as described above, the laser has to achieve the following specifications: a) Direct modulation speed: > 10 GHz, b) Extinction ratio: >5:1, c) Overall power dissipation: < 2 mW, d) Optical output power: > 0.5 mW d) integrated into dense arrays (~100/cm2, scalable to 1000's/cm2).

PHASE I: Prepare a feasibility study for the concept design of a directly modulated, polarization switched laser with capability of modulation of >10GHz with power dissipation <2mW, with optical output power of > 0.5 mW. Define the process and fabrication steps needed in order to assess manufacturability of the lasers in dense arrays. Complete simulations to backup the claims that the device can reach these goals. Assess the feasibility to extend these concepts to long wavelengths (1.3 and 1.55 µm). As part of the final report, plans for Phase II will be proposed.

PHASE II: This phase will complete the detailed design from Phase I. A concept prototype shall be demonstrated that is a >10GHz laser with low power dissipation < 2mW, drive voltage swings <10mV and output optical power of >0.5mW at 850nm with >5:1 modulation depth. Nano-fabrication techniques to enable ultimate high volume manufacturing will be assessed. Military robustness and functionality should be assessed. At the end of Phase II, the Transition Readiness Level (TRL) of this technology will be rated as "4 – Component and/or bread-board validation in laboratory environment".

PHASE III: There are both commercial and military applications for this technology. Commercial applications include: optical interconnects for high end servers and routers, high performance signal processing and supercomputing. Military Applications: LADAR, Supports Transformational Communication Architecture, integrated "Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance"

(C4ISR) optical systems, synthetic aperture radar, signal image processing, communication routers, and free space optical communication.

REFERENCES:

1. G. Verschaffelt, J. Albert, M. Peeters, K. Panajotov, J. Danckaert, I. Veretennicoff, H. Thienpont, F. Monti di Sopra, S. Eitel, R. Hoevel, M. Moser, H. Zappe, K. Gulden, "Polarization switching and modulation dynamics in gain- and index-guided VCSELs", Proceedings of the SPIE, vol. 3946, (2000), pp. 246-57

2. C. Chun, F. Sadjadi, "Polarimetric laser radar target classification", Optics Letters, Vol. 30: Issue 14 (2005), pp. 1806-1808

KEYWORDS: Lasers, Polarization, LADAR

ST092-004 TITLE: Novel Methods for Sensor Quieting in Turbulent Flows

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop a design to quiet acoustic sensor in turbulent flow by more than 20 dB. The design should be scalable to apertures of thousands of sensors with spacing between the sensors of six inches or less.

DESCRIPTION: Acoustic sensors in a turbulent flow field are subjected to large and fluctuating pressures due to this flow. This flow noise represents a noise floor that severely limits the ability of an acoustic sensor to detect quiet acoustic signals. Although methods for mitigating this effect have been studied for many years, breakthroughs that provide a realistic, scalable capability for large apertures have not been obtained.

Recent work in micro-mechanical systems (MEMS) provides one avenue for a potential breakthrough in this area. The local flow over a sensor can be sensed and then manipulated using a variety of techniques. This is active flow control, in the sense that the local flow field is sensed and mitigated over a scale equal to the size of an individual sensor. The desired end state is relaminarization of the flow across the sensor.

DARPA is looking for innovative proposals that will develop methods of local, active flow control. The flow can be manipulated by fluid injection, suction, temperature or MEMS devices that alter the local shape of the surface around the acoustic sensor. Techniques of interest should be scalable to practical apertures that may be constructed from thousands of acoustic sensors. This consideration will require careful attention to power, processing and manufacturing processes. Ideally, an acoustic sensor or sensors with the required flow control can be manufactured as a unit to provide scalability.

The proposed effort should include analysis and simulation as required to verify the design and determine quantitative quieting projections. Subsequent phases, if awarded, would focus on building and testing the sensor package and manufacturing technology needed to mass produce the design.

PHASE I: The goal of the Phase 1 effort is to develop a design for a sensor package that would mitigate flow noise more than 20 decibels over acoustic frequencies ranging from 50 Hz to 20 kHz. The proposed effort should include analysis and simulation as required to verify the design and determine quantitative quieting projections.

Phase 1 deliverables will include design data, and a package of analysis and simulation to confirm that the design meets the goal.

PHASE II: Phase 2 of this effort will be to build a prototype sensor package as designed and test the package in a water tunnel or other suitable environment. The objective is to validate the Phase 1 design experimentally. An additional objective will be to determine manufacturing methods for mass production of the device and project manufacturing costs if the units are procured in quantities of one thousand or more.

The overall goal is to produce a validated prototype at a Transition Readiness Level of four. The deliverables for this phase will be a test plan, a report with design data for the prototype and experimental data validating the performance of the prototype and a report on required manufacturing capability and projected acquisition costs.

PHASE III: In Phase 3 the design, manufacturing and cost data will be transitioned to manufacture with the goal of developing a capability to manufacture the sensor packages in large quantities. The transition target will be submarine acoustic sensing arrays with the goal of providing greatly improved sonar capability to these platforms. In Phase III, the sensor packages will be used to develop suitable apertures that will be at a Transition Readiness Level of six. At that point, customers at the Naval Sea Systems Command will develop the technology into an operational capability.

There are multiple commercial applications for the technology in oceanographic sensors, industrial flow control, aerospace and biotechnology.

REFERENCES:
1. “Advanced Flow Control Using MEMS – otherwise I cannot find the document”, C. Warsop, 5th Community Aeronautical Days, 2006.

2. “An Integrated MEMS System for Turbulent Boundary Layer Control”, T. Tsao et. Al., 1997 International Conference on Solid-State Sensors and Actuators, June, 1997.

3. “Sensor Flow-Induced Self Noise Reduction”, G. Lauchle and S. Park, Technical Report TR-02-016, The Applied Research Laboratory, Pennsylvania State University, Oct. 2002

4. “Manufacture of Micro-sensors and Actuators for Flow Control”, G.G. Arthur et. al., Microelectronic Engineering 83, 2006, p. 1205-1208.

5. El Hak, M., “Flow Control: Passive, Active and Reactive Flow Management”, Cambridge University Press, March, 2007.

KEYWORDS: Acoustic sensor, Flow noise, MEMS

ST092-005 TITLE: Proliferated Multi-Functional Satellite Constellations

TECHNOLOGY AREAS: 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: Define how next generation proliferated constellations of near identical or self coordinating multi-functional satellites can replace, enhance or augment existing space based capabilities, followed by demonstration of critical component and/or system technologies.

DESCRIPTION: Small satellites have become increasingly common over the last several decades with many small entrepreneurial companies, even universities developing and flying satellites. However, with only a few exceptions small satellites have not migrated into mainline military satellite systems, nor have single small satellites yet proven particularly useful for most military missions. DARPA seeks to explore new architectures for small to medium size, proliferated and multi-functional satellite constellations and their enabling technologies. Technological trends facilitating proliferated, multi-functional satellite architectures include modern networking, computing and high bandwidth communications; the ongoing computer/software revolution enabling affordable design, integration and test; micro-miniaturization of electronics and satellite components; high power, light weight electrical energy enabled by the DARPA Fast Access Spacecraft Testbed (FAST) program; and on-orbit servicing via robotics enabled by the DARPA Front-end Robotic Enabling Near-term Demonstrations (FREND) program.

The offeror must demonstrate a clear understanding of the mission, concept of operation and system applications for the proposed satellite architecture(s). Moreover, when compared to today's space systems the offeror must demonstrate the proposed system will offer dramatically cheaper solutions, new capabilities or both. Potential approaches could range from swarms of nano- or small- satellites enabling distributed apertures with advanced propulsion technologies to satellites that physically connect on-orbit to deliver arbitrarily large apertures. Satellites may be small or large, but notionally are largely common, multi-functional platforms that benefit from economy of scale manufacturing and operations. Applications could support any of today's space missions or new capabilities such as ultra high bandwidth communications, tracking or high resolution radar, selectable optical resolution tactical or strategic imagery, etc.

Similarly, offeror's must demonstrate a clear understanding of both innovative system and component technologies that support their proposed architecture and the advantages for various military and commercial needs. Whether the concept is swarms of coordinating satellites flying in formation or many identical platforms that self assemble on orbit, the enabling technologies must be defined and risk reduction approaches identified. Although not complete, potential enabling technologies that could facilitate proliferated, multi-functional satellite architectures include micro-miniaturization of electronic, sensor and payload systems; phased array or traditional antennas for communications and radar; light weight composite and nano-materials; affordable and efficient manufacturing technologies; advanced radiation resistant solar cells; light weight energy storage technology; and rocket thrusters including new, more efficient electric propulsion that could dramatically enhance formation flying and mobility. Offeror's may elect to design, fabricate and test an entire modular satellite or only critical components.

PHASE I: Identify potential system level and technology applications of the proposed innovation. Although multiple applications supporting a comprehensive military architecture are encouraged, to help assess the military utility the offeror shall evaluate at least one architecture that employs multiple radar and/or communications apertures in either; 1) distributed, coordinated and co-orbiting satellites employing efficient and long-life propulsion techniques; or 2) self assembling flight platforms that fly independently, then physically dock with one another to deliver arbitrarily large apertures. Although not required, consideration may be given to using the DARPA FAST program technology to deliver high power and/or efficient orbit transfer using electric propulsion, and the DARPA FREND program technology for a robotic servicing platform.

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 architectures and 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 3 and 5. 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: The offeror shall 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 STTR 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. http://www.rand.org/pubs/research_briefs/RB92/index1.html (Distributed satellite constellations).

2. AIAA Paper 2008-7933, 9-11 Sep 2008 (Hierarchical Infrastructures for Integrated Space Operations).

3. http://www.darpa.mil/tto/programs/fast.htm (DARPA FAST program, light weight and high power solar electric array).

4. http://www.darpa.mil/tto/Programs/frend.htm (DARPA FREND program, robotic arm demonstration).

KEYWORDS: Small satellite, Distributed constellations, Distributed, Architectures, Space, Satellite, Constellation, Phased array, Radar, Antenna, Communications.