

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**  
***FY2007 STTR Proposal Submission***

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

DARPA has identified technical topics to which small businesses may respond in the fiscal year (FY) 2007 STTR solicitation. Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although they are unclassified, the subject matter may be considered to be a "critical technology" 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. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included followed by full topic descriptions. The topics originated from DARPA technical program managers.

**ALL PROPOSAL SUBMISSIONS TO DARPA MUST BE SUBMITTED ELECTRONICALLY THRU WWW.DODSBIR.NET.**

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR website at <http://www.dodsbir.net/submission>. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **6:00am EST, 21 March 2007 deadline**. A checklist has been prepared to assist small business activities in responding to DARPA topics. If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

**Acceptable Format for On-Line Submission:** All technical proposal files must be in Portable Document Format (PDF) for evaluation purposes. The Technical Proposal should include all graphics and attachments but should not include the Cover Sheet or Company Commercialization Report (as these items are completed separately). Cost Proposal information should be provided by completing the on-line Cost Proposal form. This itemized listing should be placed as the last page(s) of the Technical Proposal Upload. (Note: Only one file can be uploaded to the DoD Submission Site. Ensure that this single file includes your complete Technical Proposal and the additional cost proposal information.)

Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD solicitation. However, your cost proposal will only count as one page and your Cover Sheet will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in submitting your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk.

DARPA recommends that you complete your submission early, as computer traffic gets heavy near the solicitation closing and slows down the system. DARPA will not be responsible for proposals being denied due to servers being "down" or inaccessible. Please assure that your e-mail address listed in your proposal is current and accurate. By the end of March, you will receive an e-mail acknowledging receipt of your proposal.

***PLEASE DO NOT ENCRYPT OR PASSWORD PROTECT TECHNICAL PROPOSAL***

**HELPFUL HINTS:**

1. Consider the file size of the technical proposal to allow sufficient time for uploading.
2. Perform a virus check.
3. Signature is no longer required at the time of submission.
4. Submit a new/updated Company Commercialization Report.
5. Please call the Toll Free SBIR Help Desk if you have submission problems: 866-724-7457
6. DARPA will not accept proposal submissions by electronic facsimile (fax) or email.

**Additional DARPA requirements:**

- DARPA Phase I awards will be Firm Fixed Price contracts.
- **If you collaborate with a University, please highlight the research that they are doing and verify that the work is FUNDAMENTAL RESEARCH.**
- Phase I proposals **shall not exceed \$99,000**, and may range from 8 to 12 months in duration. Phase I contracts cannot be extended.

- DARPA Phase II proposals must be invited by the respective Phase I DARPA Program Manager. Phase 2 invitations will be based on the technical results reflected in the Phase I contract and/or final reports as evaluated by the DARPA Program Manager utilizing the criteria in Section 4.3. 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.

Prior to receiving a contract award, the small business **MUST** be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-888-227-2423 or Internet: <http://www.ccr.gov>.

The responsibility for implementing DARPA's Small Business Technology Transfer (STTR) Program rests with the Contracts Management Office. The DARPA SBIR/STTR Program Manager is Connie Jacobs, see address below. DARPA invites small businesses, in cooperation with a researcher from a university, an eligible contractor-operated federally funded research and development center (FFRDC), or a non-profit research institution, to submit proposals thru the DoD website [www.dodsbir.net/submission](http://www.dodsbir.net/submission).

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**

**Attention: CMO/SBIR/STTR**

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**Home Page <http://www.darpa.mil>**

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

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I - page 7), twice the weight of the other two evaluation criteria. PLEASE NOTE THAT MANY OF THE WEAKEST PROPOSALS SCORED LOW ON EVALUATION CRITERIA "C" "THE POTENTIAL FOR COMMERCIAL (GOVERNMENT OR PRIVATE SECTOR) APPLICATION AND THE BENEFITS EXPECTED TO ACCRUE FROM THIS COMMERCIALIZATION. DARPA IS PARTICULARLY INTERESTED IN THE POTENTIAL TRANSITION OF STTR RESULTS TO THE U.S. MILITARY, AND EXPECTS EXPLICIT TREATMENT OF A TRANSITION VISION IN THE COMMERCIALIZATION-STRATEGY PART OF THE PROPOSAL. THAT VISION SHOULD INCLUDE IDENTIFICATION OF THE PROBLEM OR NEED IN THE DEPARTMENT OF DEFENSE THAT THE STTR RESULTS WOULD ADDRESS, A DESCRIPTION OF HOW WIDE-SPREAD AND SIGNIFICANT THE PROBLEM OR NEED IS, AND IDENTIFICATION OF THE POTENTIAL END-USERS (ARMY, NAVY, AF, SOCOM, ETC) WHO WOULD LIKELY USE THE RESULTS. THE SMALL BUSINESS MUST DEMONSTRATE UNDERSTANDING OF THE END USE OF THEIR EFFORT AND THE END USERS.

ALL SELECTION/NON-SELECTION LETTERS WILL BE SENT TO THE PERSON LISTED AS THE "CORPORATE OFFICIAL" ON THE PROPOSAL.

As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

- Cost proposals will be considered to be binding for 180 days from closing date of solicitation.
- **Successful offerors will be expected to begin work no later than 30 days after contract award.**
- For planning purposes, the contract award process is normally completed with 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

## **DARPA STTR 07 Topic Index**

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## DARPA STTR 07 Topic Descriptions

ST071-001      TITLE: Atom Interferometer Modeling Tool

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors, Weapons

OBJECTIVE: Assess the feasibility of producing a software-based atom interferometer modeling and design tool. The tool should integrate relevant capabilities of 3D computer aided design tools with thermal, mechanical, electromagnetic, and quantum-mechanical modeling and visualization capabilities.

DESCRIPTION: Atom interferometry is a recently established precision measurement technique that results from the interference between multiple paths of atomic ensembles, much like optical interferometry results from interference between different paths of a beam of light. The use of laser-cooled ensembles of atoms as input to atom interferometers using pulses of light as the atom optical elements has enabled precision gravimetry, measurements of fundamental constants, and the demonstration of a high-performance gyroscope. This rapid advance in laboratory measurement capabilities has led to a program to produce atom interferometer-based sensors for inertial navigation. One of the challenges inherent in such a program is to understand the interplay between the pristine environment of the atoms in an ultra-high vacuum system and the electromagnetic radiation present from the various sensor system components. This simulation must be done accurately enough to ensure the physical system design does not impede the desired measurement.

For example, to laser cool atoms, one must produce a significant magnetic field gradient. Many techniques have been used to do so, including simple electromagnet coils composed of wrappings of standard wire and lithographed conductors on so-called "atom chips." Design of such structures and devices requires defining a 3-dimensional geometry of a conductor and substrate with real physical properties such as resistance and thermal conductivity, which determines their steady-state response to currents that flow through them. These structures (along with others) must in turn be used to calculate the magnetic field within a certain volume of interest at a given time. The steady-state and dynamic behavior of atoms exposed to this environment (as well as other relevant effects such as residual optical, electric, and magnetic fields) could then be computed via quantum mechanically-derived models; the results of these calculations would provide an understanding of useful physical parameters such as atom trap and atom waveguide locations and strengths. A successful design tool must provide an environment capable of performing the following minimum operations with appropriate visualization capabilities for each: place 3-dimensional objects with realistic materials properties (mechanical, electrical, and thermal) in a specific orientation in 3D space; calculate electrical current (profile) passing through the conductor; calculate vector magnetic field in 3D due to current flowing through the wire; sum magnetic fields produced from multiple sources in 3D; allow specification of laser beam propagation paths, to include a (spatially varying) non-uniform transverse profile and specified frequency (and polarization) content of the beam; calculate magnetic or magneto-optical trap frequencies, locations, and atomic populations given atomic background pressure; simulate evaporative cooling of atoms in magnetic potential; simulate atom-laser interactions to include microwave and 2-photon Raman interactions; simulate motional dynamics of atoms in 3D environment; incorporate method to refine calculations for physically imperfect conductors.

PHASE I: Prepare a report that identifies the software design architecture and core modeling requirements, to include relevant quality assurance test scenarios. During the first phase, the performer will propose the overall software architecture and identify significant technical hurdles to integration. A preliminary design review will be held, and a report will be generated that proposes model integration (to include any relevant licensing) plans for Phase II.

PHASE II: The design from Phase I will be finalized. Incremental software builds will integrate increasing functionality into the core architecture and refine the user interface based on end-user testing. Prototype (beta-version) software will be packaged and delivered, including user documentation and any necessary installation routines.

PHASE III DUAL USE APPLICATIONS: The final modeling tool should be useful for a wide range of applications beyond atom interferometry, military and commercial. Modeling tools would dramatically speed the

design process for military sensors used for magnetic and inertial sensing. Commercial manufacturers of atomic beam-based clocks could use the design tool to predict performance characteristics of component and system designs before committing to hardware construction. Laboratory atomic physics researchers could utilize the modeling tool to design experimental apparatus for a wide range of investigations, enabling more rapid advancement in research.

#### REFERENCES:

1. Berman, P.R. (ed.), Atom Interferometry, Academic Press, 1997.
2. Peters, A., K. Y. Chung, and S. Chu, High-precision gravity measurements using atom interferometry, Metrologia 38, 25-61, 2001.
3. Wicht, A., J.M. Hensley, E. Sarajlic, and S. Chu, A Preliminary Measurement of the Fine Structure Constant Based on Atom Interferometry, Physica Scripta T102, 82-88, 2002.
4. Gustavson, T.L., P. Boyer, and M. Kasevich, Precision Rotation Measurements with an Atom Interferometer Gyroscope, Phys. Rev. Lett. 78, 2046-2049, 1997.
5. Reichel, J., W. Hänsel, and T. W. Hänsch, Atomic Micromanipulation with Magnetic Surface Traps, Phys. Rev. Lett. 83, 3398-3401, 1999 and references within.

KEYWORDS: Atom Interferometer, Atom Chip, Modeling, Computer Aided Design, Layout, Quantum Monte Carlo

ST071-002 TITLE: Portable Lightweight Rescue Tools

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop integrated energy storage, power transmission, and end effector technologies that will enable a rescue spreader with a total system weight of less than 25 lb.

DESCRIPTION: The need for a rescue spreader capability during ground vehicle and aircraft accident rescue operations is critical since victims are often trapped within a metal vehicle frame that is too strong to be bent with human powered pry bars. Current rescue spreader systems range in weight from 60 to 125 lbs and are comprised of separate power units and end effectors connected by a heavy hydraulic line or electrical cable. The complexity and weight of these systems makes them difficult to carry over rough terrain or deploy during airborne rescue. We seek novel concepts for energy storage, power delivery, and end effector materials and design that will combine to deliver a rescue spreader that will operate for 20 minutes between refuel (or equivalent process) while delivering 15,000 lb of force over a 12 inch stroke with a 20% duty cycle in a total system package of less than 25 lb. The rescue spreader must also be amenable to long term storage, safe handling by trained personnel during operation, safe handling by untrained personnel when not in operation, and safe transportation in both ground and air vehicles.

PHASE I: Perform a benchtop demonstration that demonstrates the feasibility of the combined energy storage and power delivery system. Prove using broadly accepted engineering calculations and modeling that the combination of the energy storage method, power delivery system, and end effector design will deliver the desired performance. The performance of the energy storage and power delivery system determined in the feasibility demonstration must be used as the basis for the proof of concept calculations.

PHASE II: Integrate the energy storage, power delivery, and end effector components into a single portable unit. Demonstrate that all desired system specifications are met in the integrated system. Fabricate 5 pre-production prototypes that meet all desired system specifications. Perform detailed engineering design of a portable lightweight rescue cutter.

PHASE III Dual Use Applications: The developed energy storage and power delivery technology will be broadly applicable to power tools used in civilian rescues and disaster relief. Common rescue tools other than spreaders that

this technology will benefit include rescue cutters, saws, and rams. The offerer is expected to aggressively pursue the commercialization of their rescue spreader into the broader rescue market.

#### REFERENCES:

1. Applications for solid propellant cool gas generator technology  
Van Der List, M.C.A.M.; Van Vliet, L.D.; Sanders, H.M.; Van Put, P.; Elst, J.W.E.C., European Space Agency, (Special Publication) ESA SP, n 555, Proceedings of Space Propulsion 2004 - 4th International Spacecraft Propulsion Conference, 2004, p 897-904.
2. Combustion properties of gas-generating pyrotechnics  
Engelen, K.; Lefebvre, M.H.; De Ruyck, J., Combustion Science and Technology, v 163, n 1-6, 2001, p 49-76
3. Design and energetic characterization of a proportional-injector monopropellant-powered actuator  
Fite, K.B.; Goldfarb, M., IEEE/ASME Transactions on Mechatronics, vol. 11, no. 2, pp. 196-204, 2006.
4. The design of alternative nonaqueous high power chemistries  
Plitz, I.; Dupasquier, A.; Badway, F.; Gural, J.; Pereira, N.; Gmitter, A.; Amatucci, G.G., Applied Physics A, vol. 4, 82, p 615-626, 2006.

KEYWORDS: High Power Density, Energy Storage, Lightweight Materials, Battery, Gas Generator, Combustion, Engine, Spreader, Cutter, Actuation.

ST071-003      TITLE: Alternative Aggregate Combat Modeling Algorithms

TECHNOLOGY AREAS: Information Systems

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 implement new, alternative strategies to reduce or eliminate the need for aggregation and disaggregation of entities and units in combat simulations. These strategies should include both sensing and shooting at an entity level (disaggregated) and at a unit level (aggregated) and provide a rational and computationally effective way of combining levels of aggregation in a single simulation system or federation without the need for aggregation, disaggregation, and/or entity control handoff.

DESCRIPTION: There have been a number of efforts to link aggregate-level and entity-level combat simulations. These have typically addressed linking some number of specific models, rather than solving the general problem. The solution often involves “disaggregating” aggregate units through a series of rules and passing those disaggregated units to the entity-level simulation to control for some period of time. Disaggregation, however, involves more than just splitting the aggregate unit into its constituent entities. It involves “process” disaggregation, breaking the task the aggregate unit was performing into entity-level tasks. It also involves disaggregating the combat phenomenology, defined here as the computation of combat effects due to shooting. This research effort will address combat phenomenology, specifically the development of new aggregate algorithms for sensing and shooting.

Aggregate simulations typically use Lanchester equations in their various formulations. Basic Lanchester equations have a number of known assumptions (in particular, that all battlefield entities are homogenous and evenly distributed) but they can provide a useful conceptual framework. This framework is often customized for particular overall situations, e.g. the variables that represent the killing ratios for Red/Blue forces are derived using complex calculations based on dependent state variables (weaponry, terrain, weather, etc.), but other complexities are more difficult to adequately characterize, e.g. defensive variables and proactive behavior such as armor, maneuver, use of terrain cover, or anti-weapons systems. Other models are built around the Qualitative Judgment Mode which has its own set of assumptions and intrinsic limitations.

Entity-level simulations typically are built around conditional probabilities, such as  $P(\text{hit})$  and  $P(\text{kill} \mid \text{a hit})$  or  $P(\text{kill} \mid \text{a shot})$ . (These algorithms are often referred to in simulation literature as Ph/Pk and Pks, respectively.) There is no sound theoretical basis for the interaction between entity-level and aggregate-level models, so it is difficult to have actors in an entity-level model interact directly with actors in an aggregate-level model. For this reason the aggregates have to be disaggregated and passed to the entity-level model for control, or vice versa.

The focus of this research is to propose alternative aggregate-level algorithms for sensing and shooting that are based on the typically-used entity-level algorithms. As an example, perhaps the Ph/Pk computations for a group of firing entities in an entity-level model can somehow be “rolled up” to compute the attrition damage to the aggregate-level unit. If such algorithms were developed, the need for aggregation, disaggregation, and entity control handoff would be reduced or eliminated.

PHASE I: Develop alternative aggregate and entity-level strategies and algorithms and demonstrate that they can interact in a seamless, theoretically-sound way and how they can be validated in a number of situations.

PHASE II: In Phase II, the researcher will be expected to implement these algorithms for a pair of simulation systems, entity-level and aggregate, such as OneSAF Objective System (OOS) and WARSIM.

PHASE III Dual Use Applications: In Phase III, the researchers will demonstrate potential uses of this technology to include simulation systems for homeland security, emergency response, civil law enforcement, large-scale wildfire response, and others.

#### REFERENCES:

1. Lanchester Equations and Scoring Systems, [www.rand.org/pubs/monograph\\_reports/MR638/app.html](http://www.rand.org/pubs/monograph_reports/MR638/app.html)
2. Dinges, John A., Exploring the Validation of Lanchester Equations for the Battle of Kursk, Abstract, [www.stormingmedia.us/71/7161/A716193.html](http://www.stormingmedia.us/71/7161/A716193.html) - 20k.
3. Sidran, D.E., A Calculated Strategy: Readings directed towards the creation of a strategic artificial intelligence. [www.cs.uiowa.edu/~dsidran/Lanchester%20Alternative.pdf](http://www.cs.uiowa.edu/~dsidran/Lanchester%20Alternative.pdf).
4. T.N. Dupuy, Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War, Falls Church, VA: Nova Publications, 1995.

KEYWORDS: Behavior Modeling, Aggregation/Disaggregation, Military Simulation.

ST071-004      TITLE: Next-Generation Behavior Composer for Military Simulation

TECHNOLOGY AREAS: Information Systems

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 new tools for the creation of entity and unit behaviors to be embedded in military simulation systems. These tools should leverage novel paradigms involving human-computer interaction so that users can apply their knowledge of the desired result without being encumbered by unnecessary details of primitives, composition rules, programming constructs, and the like.

DESCRIPTION: The OneSAF Objective System (OOS) has made a significant step forward in allowing non-programmers to create new semi-automated behaviors in the simulation. A behavior is a complex, tactical task performed by combat entities and units within the simulation. The OneSAF program has a well-defined behavior modeling language, a robust initial set of behaviors, and a graphical tool to allow non-programmers to modify or

create behaviors without writing or recompiling software. The current behavior composer uses a graphical programming language to do this. This language and the Behavior Composer graphical user interface allow the user to combine and compose more primitive behaviors into aggregate or “higher-level” behaviors using a graphical flow-chart-type metaphor. Newly-defined behaviors can then be used in the creation of more advanced behaviors, and so on.

The behavior composer, however, still requires the user to have some familiarity with the notion of behavior primitives, composite behaviors, and programming constructs, such as iteration, conditional, and looping statements. In addition, it can be difficult for the user to understand how a completed or draft behavior will really work in a variety of situations, perceive anomalies or gaps in the intended execution of the behavior, or have confidence that the behavior is robust under the desired conditions. There are at least two factors underlying this difficulty: completeness under a variety of environmental conditions and factors and the robustness of the defined behaviors, especially when a defined behavior is itself used as a composition primitive.

Another impediment to a more natural behavior definition system is the general problem of sketch recognition. It would be highly advantageous if the user could communicate with the computer by sketching, instead of laboriously dragging and dropping icons in a pre-defined graphical user interface.

Two basic tenets of human-computer interaction (HCI) are the computer should do what it does best, thus allowing the human to what he or she does best, and the computer should support the human in the achievement of the human’s goals. In this domain, the computer could use its knowledge of the library of behaviors, the composition and control-flow rules, and other knowledge to allow the user to iteratively and interactively converge on the desired behavior in a natural fashion. The result should be a more powerful and natural behavior creation capability that reduces the problems of completeness and robustness. If the computer had the ability to recognize hand sketched input, this could greatly increase the utility, power, and ease-of-use of the system.

The goal of this research effort is to develop new paradigms and new tools and systems for computer-human interaction that could be used by a next-generation behavior composer to interactively work with the user to modify or create behaviors. The vision is for the user to interactively and iteratively draw a storyboard of the behavior, as the user might do when instructing new soldiers in the proper execution of the tactical behavior. The system is intelligent enough to query the user for more information, ask elucidating questions, and interact with the user in a natural way, much like new soldiers or students in a teaching situation.

While it is envisioned that the developed tool could benefit many simulation systems and tools, the focus of this research is on the human-computer interactions and the development of the tool. The purpose of this research is not to define a new behavior modeling language or simulation system. To focus this research effort on the intended area, the use of OOS; the OOS modeling language; and OOS entities, units, and behaviors is specified. Researchers who propose a project under this STTR should coordinate with the OneSAF program office for access to OOS software and documentation and present with the proposal indication that the program office will grant access.

**PHASE I:** In Phase I, the performer will outline the computer human interaction (CHI) technologies and techniques envisioned to implement a next-generation behavior composer. Story boards or other prototype mock-ups are expected. As part of the final report, plans for Phase II are required. There is no expectation that a prototype would be built during Phase I, but the report must address how the performer plans to implement a prototype in Phase II and how that prototype will comply with the OneSAF Objective System (OOS) architecture and interfaces. In addition, the plan for Phase II must address the set of behaviors that will be built with the tool in Phase II to demonstrate the efficacy of the proposed approach.

**PHASE II:** In Phase II, the researcher will be expected to build a system that fully supports the OOS behavior modeling language and could potentially supplement or replace the current composer tool. The researcher will demonstrate that a range of behaviors can be created and modified with the developed tool. As part of the final report for Phase II, the researchers will present their plans for Phase III, including other simulations with which the next-generation composer tool will be integrated.

**PHASE III Dual Use Applications:** Direct potential uses of this technology include simulation systems for homeland security, emergency response, civil law enforcement, large-scale wildfire response, and others. In Phase

III, the researchers will apply the proposed tool to a simulation system other than OOS and/or a domain other than combat modeling.

#### REFERENCES:

1. Surdu, J.R., One Semi-Automated Force (OneSAF) Objective System (OOS): Program Overview [www.amso.army.mil/smart/conf/2006/4may06/Breakout%201-M&S%20Tools/OOS,Small\\_Common\\_v10.ppt](http://www.amso.army.mil/smart/conf/2006/4may06/Breakout%201-M&S%20Tools/OOS,Small_Common_v10.ppt)
2. Karr, C.R., OneSAF Behaviors, OneSAF User Conference, 1993. [http://list.onesaf.org/html/baselined/briefs/OneSAFUserConf\\_Behaviors.pdf](http://list.onesaf.org/html/baselined/briefs/OneSAFUserConf_Behaviors.pdf)
3. Henderson, C., Grainger, B., Composable Behaviors in the OneSAF Objective System, Proceedings of the 2002 Interservice/Industry Training, Simulation, and Education Conference, Orlando, Florida, December 2-5, 2002. [http://list.onesaf.org/html/baselined/papers/iitsec\\_02\\_final.pdf](http://list.onesaf.org/html/baselined/papers/iitsec_02_final.pdf)
4. Henderson, C., Grainger, B/. Behavior Modeling in the OneSAF Objective System (accompanying presentation to [3]) [http://list.onesaf.org/html/baselined/papers/iitsec\\_02\\_final.pdf](http://list.onesaf.org/html/baselined/papers/iitsec_02_final.pdf)
5. Alvarado, C., Davis, R., SketchREAD: a multi-domain sketch recognition engine, Proceedings of the 17th annual ACM symposium on User interface software and technology Santa Fe, NM, USA 2004, Abstract and full paper available here: <http://portal.acm.org/citation.cfm?id=1029637&dl=acm&coll=&CFID=15151515&CFTOKEN=6184618>
6. Forbus, K. Usher, J. and Chapman, V. 2003. Qualitative spatial reasoning about sketch maps. Proceedings of the Fifteenth Annual Conference on Innovative Applications of Artificial Intelligence, Acapulco, Mexico. [http://www.qrg.northwestern.edu/papers/Files/QSMAP03\\_distribution.pdf](http://www.qrg.northwestern.edu/papers/Files/QSMAP03_distribution.pdf)

KEYWORDS: OneSAF, Behavior Composition, Military Simulation.

ST071-005 TITLE: Open Source Information Geospatial Overlay (OSIGO)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop technology for the aggregation and reasoning of geo-referenced open source news and other information as an overlay to geospatial imagery.

DESCRIPTION: As part of their intelligence production activities, military image analysts make use of open source information relating to the location under analysis. Collecting and summarizing this information causes a considerable delay in the production of geospatial intelligence products.

Commercial geospatial information services encode relatively static data (e.g., roads, dining, parks, and lodging) as “layers” on geospatial imagery. We envision the addition of new “knowledge layers” that convey dynamic information available from open textual sources such as news, web logs, and press releases. This content would be summarized and presented to the user in a concise manner. OSIGO technology would allow military image analysts to integrate open source knowledge into their analyses while maintaining focus on images themselves, increasing their analytical efficiency. The technology should be able, for example, to inform the image analyst of the occurrence of an oil spill in the geographical area shown in an image at the time the image was collected, thereby explaining the presence of a concentration of ships. Automated reasoning over the geo-referenced knowledge could potentially provide further aid to analysts in their interpretations of imagery.

DARPA seeks innovative approaches in natural language processing, knowledge based systems and other technologies for OSIGO. Research that exploits whatever performance advantages can be obtained by focusing on particular regions of space is encouraged; direct application of general-purpose natural language processing or

knowledge based reasoning methods to the geospatial domain is not desired. Proposers must also demonstrate familiarity with geospatial representational languages such as the Keyhole Markup Language (KML) and Geography Markup Language (GML) and proposed approaches must show compatibility with one or more established markup languages.

PHASE I: Investigate design approaches leading toward an Open Source Information Geospatial Overlay. Identify the critical technical challenges involved in development of OSIGO technology. Select promising approaches and demonstrate viability through experimentation. Evaluate potential benefit to commercial and military geospatial applications through system analysis.

PHASE II: Apply Phase I results, data, and analysis to develop a prototype that demonstrates the efficacy of OSIGO technology. Evaluate the performance of the prototype through experimentation with commercially available geospatial imagery and open source text documents.

PHASE III Dual Use Applications: Development of OSIGO technology would result in a significant enhancement to geospatial analysis tools. The addition of multiple OSIGO “knowledge layers” could potentially add value to the geospatial imagery provided by commercial companies.

#### REFERENCES:

1. National Geospatial Intelligence Agency, “National System for Geospatial Intelligence Statement of Strategic Intent”. November 2005 <[http://www.nga.mil/NGASiteContent/StaticFiles/OCR/nsg\\_strategic\\_intent.pdf](http://www.nga.mil/NGASiteContent/StaticFiles/OCR/nsg_strategic_intent.pdf)>.
2. Google, “Google Earth KML Documentation”. July, 31 2006 <<http://earth.google.com/kml/>>.
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KEYWORDS: Geospatial Intelligence, Knowledge Representation, Formal Semantics, Ontology, Reasoning, Natural Language Processing, Information Extraction.

ST071-006 TITLE: Micro/Nano -Fabrication for Low Volume Electronics

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Develop innovative approaches for cost effective, high resolution micro/nanofabrication for low volumes

DESCRIPTION: Current methods/technologies for microfabrication, especially for microelectronics, are dominated by techniques optimized for very high volumes. DOD needs for custom electronics are typically for much lower volumes, and current commercial microelectronic manufacturing methods are not cost-effective in this regime. We seek novel approaches for cost effective high resolution micro/nano – fabrication methods optimized for low volumes. Such methods may include maskless approaches or hybrid methods where maskless and mask-based techniques are combined in innovative ways.

PHASE I: Demonstrate feasibility of proposed micro/nano – fabrication method. Determine, using simulation and/or basic experiments, what the expected throughput (wafers per hour or area per unit time) and resolution of the proposed method is. Propose realistic fabrication scenarios for typical micro/nano – electronic, photonic or Micro Electrical Mechanical (MEMs) components.

PHASE II: Develop prototype system demonstrating throughput/resolution performance estimated in PHASE I. Such a system should be capable of patterning reasonably large areas (wafer size) in reasonable times (several wph at least). Fine tune realistic fabrication scenarios for typical micro/nano – electronic, photonic or MEMs components

PHASE III DUAL USE APPLICATIONS. Micro-nanofabricated component complexity and cost effectiveness of method should be broad enough for both DoD and commercial low-volume applications. Commercial applications include rapid prototyping or application specific circuits such as Radio Frequency (RF)-Application Specific Integrated Circuits (ASICs.)

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KEYWORDS: Low-Volume Manufacturing, Micro/Nano – Fabrication, Maskless Lithography, Hybrid Lithography/Patterning, Asics, Rapid Prototyping

ST071-007 TITLE: Innovative Methods for Ultra-Low Power Electronic Circuits

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

OBJECTIVE: Develop innovative approaches for ultra-low power electronic circuits.

DESCRIPTION: Power efficiency (operations/watt) is a key metric of current DoD electronic systems. Application examples include mobile communications, micro-air vehicles, sensors and space-based assets. Achieving efficient low-power performance is growing increasingly difficult especially with the current trends of increasing leakage current with each new technology node. Novel approaches are sought for achieving ultra-low power performance for electronic devices and circuits. Some possible areas to be explored are novel device concepts enabling ultra-low power or novel design approaches including subthreshold operation or 3D topologies enabling ultra-low power circuits.

PHASE I: Demonstrate feasibility of ultra-low power device concept or design method. Simulations or parametric modeling are sufficient for the limited scope of this phase. For designs methodologies, application to a limited set of circuit cells is sufficient at this point.

PHASE II: Build prototype device demonstrating ultra-low power performance potential. Alternatively, demonstrate ultra-low power circuit designs for circuits of moderate complexity. Use of parametric models based on typical standard Complimentary Metal-Oxide Semiconductor (CMOS) processes is desirable. Possible demonstration of ultra-low power designs in 3D topologies.

PHASE III Dual-Use Applications: DoD relevance include radio/comms, (radio Frequency) RF-microwave, unattended-sensors. Dual use applications include mobile communications and computing.

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KEYWORDS: Ultra-Low Power, Electronics, Circuits, Devices, Subthreshold

ST071-008 TITLE: Directly Modulated High-Speed, Low-Power Integrated Lasers

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Develop and manufacture very high speed (>20GHz) directly modulated integrated laser arrays which also have very low power dissipation (<2 mW per laser) for optical interconnects at the board and chip levels, and short-haul high-density optical communication applications.

DESCRIPTION: On-chip clock rates of silicon microprocessors are expected to reach well into the 10's of GHz in the next 5 years. Consequently, the data throughput between electronic boards, chips, and processing cores within a chip will exceed multiple terabits/sec in the coming years. Optical Interconnect (OI) technology is gaining acceptance as a solution to the data rate and power consumption issues for board-board interconnects, and in the future OI is likely to be applied to inter-chip and eventually to the intra-chip interconnects as well. One method relies on lasers placed external to the chip, with external or internal modulators used to apply high-speed electronic signals to the optical carrier as it is routed from chip to chip or within a chip. While this is technically viable, this scheme requires additional packaging costs associated with a high-precision optical interface. As packaging costs constitute roughly 80% of the total costs, additional optical interfaces are undesirable and there is a need for a directly modulated lasers which can reach speeds >20Gbps and which have low overall power dissipation (<2 mW), with output powers of ~ .5 mW, and can be integrated in dense arrays (~100/cm<sup>2</sup>, scalable to 1000's/cm<sup>2</sup>).

Conventional lasers are bandwidth limited via: (a) resistor-capacitor (RC) limits due to charging and discharging of the laser and electrode capacitance; (b) carrier transport effects due to the movement and redistribution of carriers in the active region; (c) heating effects caused by current modulation that reduce the intrinsic bandwidth (f<sub>max</sub>); (d) mode competition effects in multimode devices. Although the intrinsic bandwidth of a laser can exceed 90 GHz, it has been shown that limits due to (a) are in the range of 10-20 GHz for the fastest lasers. Driving lasers harder to get >10 Gbps is highly undesirable as it increases current density, substantially lowers lifetime, and increase power dissipation. The problem of chirp has the effect of limiting the usefulness of the laser. The effect of chirp will be studied in this program and methods to eliminate/reduce this to achieve the program goals will be delineated.

Current laser technologies are optimized for long distance telecommunication and data communication applications, and do not have the necessary characteristics (power dissipation, form factor, cost, signal integrity) needed for interconnects between and on high-speed electronic chips. There has been considerable work in optical backplane technology during the last few years in the commercial sector as well as by DARPA funded activities; however, there has not been a focus on development of very high speed lasers which have low power dissipation.

This program focuses on the development of very high speed (>20 GHz) directly modulated optically laser technology which also has very low power dissipation. Of particular interest is that these lasers be manufacturable and hence cost effective in these applications. This development would have considerable benefit to future military

and commercial applications. Seamless transition between chip-to-chip and intra-chip interconnects within a processing architecture promises to lead to flatter memory hierarchy as well as to achieve scalability in implementing large, distributed algorithms in future military applications. The overall objective is to demonstrate the feasibility of being able to extend the current limits of laser bandwidth from the ~20GHz to potentially ~80GHz with very small <10mV drive voltage swings. The goal is for a 0.5mW at 850nm wavelength and >5:1 modulation depth. A critical aspect is to develop a firm theoretical background of the switching mechanism and prove that modulation rates approaching 100Gbps is possible. This effort enables the creation of a single-mode, semiconductor laser with very high-modulation speed (i.e., in excess of 40 GHz and potentially the intrinsic bandwidth (f<sub>max</sub>) of the laser). Also of interest is the ability of this new device to (a) decouple the laser turn-on current from the switching mechanism resulting in a low (i.e., near-zero) chirp; (b) provide a constant-current, constant electrical power device, thereby reducing the difficulty of thermal dissipation, and packaging; (c) achieve high-speed and high extinction ratio simultaneously by decoupling the bias points from the extinction ratio; (d) inherently stabilize the wavelength as a function of modulation speed or format; (e) ability of the device to be used as an optical amplifier/modulator.

**PHASE I:** Prepare a feasibility study for the concept design of a directly modulated laser with capability of modulation of >20GHz with power dissipation <2mW, with optical output power of ~.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 1.5 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 >20GHz laser with low power dissipation < 2mW, drive voltage swings <10mV and output optical power of ~0.5mW at 850nm with >5:1 modulation depth. A critical aspect is to develop a firm theoretical background of the switching mechanism and prove that 100Gbps modulation is feasible. Nano-fabrication techniques to enable ultimate high volume manufacturing will be assessed. Military robustness and functionality should be assessed.

**PHASE III Dual Use Applications:** 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: 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.

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**KEYWORDS:** Lasers, High-Speed, Optical Interconnects, Free-Space Communications, Manufacturing, Integrated Circuit Fabrication And Packaging.

ST071-009      TITLE: Universal Imaging Sensor

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Prepare a Phase I feasibility study to develop an imaging sensor that is small, inexpensive, self-sustainable over a long time period (months-years), capable of determining the nature of objects coming within its field of view (within a limiting list of profiles) with very low probability of false alarm, and can return an image triggered by such profiles to a remote base station, for further action.

DESCRIPTION: Field-deployable sensors have been in development for many years, and recognized as a valuable component of modern defense since the Viet-Nam War. However, their utilization has been plagued by their limited sensing capability, size, cost, false positives, etc. Great efforts have been made to overcome these difficulties with only modest success so far.

It must be admitted that the most desirable sensor would be a human, with his considerable visual sensing capabilities, sustaining himself in a dangerous locality for long periods but communicating instantly when threats materialize. Lacking that, an imaging sensor would be most useful, if it could dependably discriminate threats from other activities within its field of view and, only then, alert the distant duty officer by transmitting a visual confirmation of the threat. (Non-imaging sensors also might be utilized, but only as triggers for visual confirmation in a networked arrangement.) Small video cameras are the closest approximation to such a capability, at present, and they suffer from a multitude of deficiencies – but most notably, an inability to assess an image and conclude that it contains a threat. Granted, the “duty officer” might make that assessment from the transmitted pictures, if only his attention span were such that he could maintain critical surveillance over banks of displays constantly conveying such images from the field. Passive imaging video alone could perform the basic functions of detection, identification and tracking of mobile threats, with greatly improved performance over present systems and with much longer range per sensor (~100 meters) and very low probability of false detections.

This program would investigate the feasibility of developing and fabricating an imaging sensor, based upon present video camera designs, but employing some degree of image processing within the sensor itself to accomplish pre-selection of the moving image detected by the pixel array and preliminary matching with expected threat profiles. The extent of this processing capability within the camera will be determined by its power source; presently, only batteries are available, but it is expected that newer compact, and longer-lived sources, such as the Micro Isotope Power Source (MIPS) developed by DARPA, will be available to extend the image-processing capability and sensor lifetime. The first performance goal of the sensor would be to identify an image from a limited data base of threat possibilities – such as human, animal or vehicle – with very low probability of false alarm; potentially, this would be extendable to many other options and with finer distinctions, such as nature of the intrusion (single soldier, squad, ...), type of armament included, etc.

This program initially would be limited to the development of a versatile imaging sensor. A follow-up effort would implement a network of such sensors with distributed image processing throughout. This network would improve the basic functions of unambiguous detection, identification and tracking of intruders to the military perimeter, with even greater range and lower false alarms.

PHASE I: Prepare a feasibility study for an imaging sensor concept. During the first phase, the performer will propose a conceptual sensor. Formal design of the concept will be performed and a preliminary design review and report will be generated. As part of the final report, plans for Phase II will be proposed.

PHASE II: The design from Phase I will be finalized. All appropriate engineering testing and validation of design issues will be performed. A critical design review will be performed to finalize the design and a prototype unit will be manufactured and tested.

PHASE III Dual Use Applications: There are numerous military applications involving perimeter defense, in areas where it is difficult or dangerous to assign military personnel, such as a battlefield environment or remote areas

where support is difficult or impossible; commercial applications include home protection from intruders when families are absent or sleeping, and monitoring of sensitive areas against unauthorized intrusion.

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KEYWORDS: Imaging Sensors, Perimeter Defense, Situational Awareness, Stealth Surveillance.

ST071-010      TITLE: Innovative Reconfigurable Wing Designs for Future Short Take-Off and Landing (STOL) Aircraft

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop innovative, shape changing wing designs which provide enhanced take-off and landing performance without the use of conventional high-lift devices.

DESCRIPTION: Future battlefield theatres will increasingly necessitate operation of military aircraft in rough, short and unconventional runways or even in a situation without a runway, placing a premium on short take-off and landing (STOL) performance. While conventional high-lift devices such as flaps and slats on wing leading and trailing edges provide improved low speed performance, they are heavy, complex and increase overall aircraft observability. DARPA sponsored research over the last decade has addressed the development of revolutionary smart and morphing wing designs which provide optimized multi-point flight performance by changing wing camber, area, span etc. Building upon prior work, the focus of this solicitation is the development of reconfigurable wing designs which specifically address improved high-angle-of-attack, low speed performance.

PHASE I: Develop innovative shape changing wing designs suitable for subsonic STOL military transport aircraft. Establish feasibility of the developed designs by analytical modeling of the wing kinematics and load-bearing structure and high angle-of-attack performance. Demonstrate, by first order analysis, improvements in take-off and landing speeds comparable to those achieved using conventional mechanical high-lift devices.

PHASE II: Design and build a scaled wing model and test in a wind tunnel to quantify performance improvements. Establish validity of the testing to full-scale aircraft. Provide assessment of power, weight and reliability benefits in comparison to conventional high-lift devices.

PHASE III Dual Use Applications: Reconfigurable wing designs will enable development of multi-mission and multi-role military combat aircraft. Such designs can also improve the performance and efficiency of commercial and military transport aircraft.

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KEYWORDS: High Angle-Of-Attack Aerodynamics, Reconfigurable Structures, STOL