DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
SBIR 2004.3 Submission of Proposals

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

DARPA has identified technical topics to which small businesses may respond in the third fiscal year (FY) 2004 solicitation (FY 2004.3). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although the topics are unclassified, the subject matter may be considered to be a "critical technology". If you plan to employ NON-U.S. Citizens in the performance of a DARPA SBIR contract, please identify these individuals in your proposal as specified in Section 3.5.b(7) of the program solicitation. A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

DARPA **NOW** requires electronic submission of Cover Sheets, Technical and Cost proposals, and Company Commercialization Report. A hardcopy is no longer required. Only proposals submitted through the on-line submission site at www.dodsbir.net/submission will be accepted or considered for award. Proposals must be prepared and submitted in accordance with the DoD Program Solicitation at www.dodsbir.net/solicitation and following the instructions below.

PLEASE DO NOT ENCRYPT OR PASSWORD PROTECT YOUR 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.

DARPA Phase I awards will be Firm Fixed Price contracts.

Phase I proposals shall not exceed $99,000, and should be a **6-month effort**.

DARPA Phase II proposals must be invited by the respective Phase I DARPA Program Manager (with the exception of Fast Track Phase II proposals – see Section 4.5 of this solicitation). Phase 2 invitations will be based on the technical results reflected in the Phase I draft and/or final report 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.

It is expected that a majority of the Phase II contracts will be Cost Plus Fixed Fee. However, DARPA may choose to award a Firm Fixed Price Contract or an Other Transaction, on a case-by-case basis.

Prior to receiving a contract award, the small business MUST be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-888-352-9333 and pressing 3 or Internet at www.ccr.gov.

The responsibility for implementing DARPA's SBIR Program rests in the Contracts Management Office. The DARPA SBIR Program Manager is Ms. Connie Jacobs.

SBIR proposals will be processed by the DARPA Contracts Management Office and distributed to the appropriate technical office within DARPA for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. **GOVERNMENT TRANSITION OF THE PROPOSED EFFORT IS VERY, VERY IMPORTANT. THE SMALL BUSINESS SHOULD INCLUDE THEIR TRANSITION VISION IN THEIR COMMERCIALIZATION STRATEGY. THE SMALL BUSINESS MUST UNDERSTAND THE END USE OF THEIR EFFORT AND THE END USER, i.e., ARMY, NAVY, AF, SOCOM, ETC.**

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

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

Successful offerors will be expected to begin work no later than 30 days after contract award.

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

The DoD SBIR Program has implemented a Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. DARPA encourages Fast Track Applications ANYTIME during the 6th month of the Phase I effort. The Fast Track Phase II proposal must be submitted no later than the last business day in the 7th month of the effort. **Technical dialogues with DARPA Program Managers are encouraged to ensure research continuity.** If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding will generally not exceed $40,000.

DARPA FY2004.3 Phase I SBIR
Checklist

Page Numbering

Number all pages of your proposal consecutively ______
Total for each proposal is 25 pages inclusive of cost proposal and resumes.
Beyond the 25 page limit do not forward appendices, attachments and/or additional references.
Company Commercialization Report **IS NOT** included in the page count.

Proposal Format

b. Cover Sheet, Technical and Cost proposals, and Company Commercialization Report MUST be submitted electronically ______

c. Identification and Significance of Problem or Opportunity ______

d. Phase I Technical Objectives ______

e. Phase I Work Plan ______

f. Related Work ______

g. Relationship with Future Research and/or Development ______

h. Commercialization Strategy ______

i. Key Personnel, Resumes ______

j. Facilities/Equipment ______

k. Consultants ______

l. Prior, Current, or Pending Support ______

m. Cost Proposal ______

n. Company Commercialization ______

SUBJECT/WORD INDEX TO THE DARPA FY2004.3 TOPICS

Subject/Keyword Topic Number

DARPA 04.3 Topic Index

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SB043-049	Agile Maneuvering Using Dynamic Control Surface Morphing

DARPA 04.3 Topic Descriptions

SB043-036 TITLE: Novel Low-cost Methods for Fabricating Compact, Vertically Integrated MEMS

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: To develop novel methods for fabricating compact, vertically integrated Microelectromechanical Systems (MEMS) at low cost.

DESCRIPTION: There are many potential applications for MEMS sensors such as environmental sensors, accelerometers, and inertial measurement units (IMU's) in weapon systems and other areas of military significance. Currently, the majority of the MEMS devices in use consist of two-chip devices: the MEMS sensor, fabricated from either poly- or single crystal silicon having suspended silicon structures, and the drive and/or readout circuitry. Electrical connections from the MEMS structure to the associated circuitry are accomplished through wire bonds. In an attempt to save chip "real estate" various techniques have been developed to enable the fabrication of integrated MEMS which contain both the MEMS sensor and necessary circuitry on the same chip (or die). Most often this type of integration is in a two-dimensional (2-D) or side-by-side layout thus placing limits on the ability to fabricate even more compact integrated MEMS. While the capability exists to fabricate complex 3-D MEMS, integrating the MEMS device in a vertical or 3-D fashion requires more work be done. To fully realize the benefits to be gained from vertically integrated MEMS requires that whatever processes are developed be tolerable to existing means of fabricating circuitry so that one could use a suitable circuit, such as complementary metal oxide semiconductor (CMOS), as the initial substrate for a given MEMS device. Further, due to limitations associated with sensor/actuator elements micromachined from poly-silicon, the highest performance will be realized from MEMS devices fabricated from single crystal silicon using bulk micromachining processes and techniques.

For maximum flexibility in fabricating vertically integrated 3-D MEMS, one would like to be able to build MEMS structures of arbitrary height and complexity through a layering method, i.e. the initial layer is patterned and etched while subsequent layers are bonded, patterned, and etched in contrast to fabricating the various device layers separately and then bonding them together. To make this a feasible and cost effective approach requires several issues to be addressed. First, to make a truly vertically integrated 3-D device would require a means for through-device electrical connectivity that could be accomplished at the wafer-scale level. Second, the materials and methods used for wafer bonding must not compromise the underlying circuitry.

The goal of this topic is to solicit innovative and novel ideas for developing compact, vertically integrated 3-D MEMS sensors suitable for use in missile and missile related weapons systems. The technology developed should be suitable for use in, but not limited to, the following types of sensors: missile maintenance, such as pressure, temperature, and propellant leak detection; detection of chemical and biological agents, and inertial systems, such as accelerometers and rate sensors. Award consideration will be based heavily upon the completeness of addressing the named concerns, the innovative nature of the technology proposed, and the economic advantages of the process(es) proposed.

PHASE I: Prepare a feasibility study for a design to fabricate a MEMS sensor as proof-of-concept of your proposed technique.

PHASE II: Develop and demonstrate a fully integrated prototype MEMS sensor device.

PHASE III Dual Use Applications: The dual use potential of the sensors and technologies from this effort are widespread. As is often the case, military requirements exceed those of industry; however, the advances made could result in making MEMS sensors much more suitable for many applications such as environmental monitoring, biomedical MEMS, RF MEMS, and rate sensing.

REFERENCES:
1. Madou, Marc J. Fundamentals of Microfabrication, Second Edition, CRC Press, 2002.
2. M. Gad-El-Jak (Editor), The MEMS Handbook, CRC Press, 2002.

KEYWORDS: MEMS, Sensors.

SB043-037 TITLE: Orthogonal Communications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a communication system that is impervious to interference.

DESCRIPTION: Develop a communication system based on the concept that by understanding the structure of the ambient electro-magnetic environment in some representative mathematical space then non-interfering communication can be achieved in some other space.

PHASE I: Develop a mathematical foundation. This phase should prove the tractability of the problem. Both analytic and small scale simulations may be performed.

PHASE II: The purpose of this phase is to demonstrate the performance of this communications concept in the presence of both natural and man made interferers. The simulations of this phase should be based on realistic technology capability assumptions so that the possibility of actually implementing this concept can be evaluated.

PHASE III Dual Use Applications: Both commercial and military systems suffer significantly from the effects of interference either natural or man made. The commercial world will benefit from greater capacity and hence increase revenue per capital investment. The military user will benefit from covertness and robustness.

REFERENCES:
1. CDMA, Principles of Spread Spectrum Communication, A. J. Viterbi, 1994.
2. Digital Communication, Lee and Messerschmidt, Addison-Wesley, 1998.

KEYWORDS: Orthogonal, Communications, Multi-User Detection.

SB043-038 TITLE: Ad Hoc Networking Over In-Building Power Lines

TECHNOLOGY AREAS: Information Systems

Topic falls within the International Traffic in Arms Regulations

OBJECTIVE: Design and build a low cost, self-contained communications system capable of supporting low data rate applications such as voice and sensor data over building power lines including operation over power transformers as well as open circuit breakers by using ad hoc networking.

DESCRIPTION: The use of wireless voice communications and unattended sensors networked using wireless communications is problematic in buildings where propagation loss due to structural members can dramatically shorten communications range. By using the existing power line infrastructure, communications can be maintained without the use of the already limited spectrum. Current residential systems for communicating over power lines operate with the constraint that all units are on the common side of a power distribution transformer. In addition, these units are powered off of the mains which may not be present in military environment and which assume that all circuit breakers are closed. In commercial structures, however, power distribution transformers isolate individual circuits. This effort proposes a low data rate (10’s of kbps) power line communications system capable of autonomous network formation and routing for operation over open circuit breakers and between multiple power transformer isolated circuits. The proposed system must be able to operate when the power infrastructure is on and off as well as minimize interference to other devices connected to the power distribution system and accept interference caused by devices connected to the power distribution system.

PHASE I: Define the proposed concept, identify critical parameters, and perform trade studies, through analysis, modeling and simulation or other methodology, to predict the performance of the proposed design. Identification and leverage of existing technology for communications over power distribution technologies and standards is encouraged.

PHASE II: Using results from Phase I, develop and validate a prototype that successfully demonstrates the capability for low data rate communications over domestic as well as international residential and commercial in building power distribution systems.

PHASE III Dual Use Applications: Technology developed on this program will have application for both commercial and military systems requiring cost effective, efficient and robust low data rate communications for use within buildings. Use by emergency personnel within a structure as well as security monitoring applications will also benefit greatly from pursuit of this technology. This technology will increase the control of security systems within structures without the need for wireless or special purpose communications infrastructure to secure a building or facility.

KEYWORDS: Ad Hoc Networking; Power Line Communications; Unattended Sensors.

SB043-039 TITLE: <u>Bio-Inspired Sensory Systems</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors

OBJECTIVE: Develop biologically-derived or biologically-inspired sensor technology for lightweight, low-cost, environmentally friendly military and commercial applications.

DESCRIPTION: Many current sensor and imaging systems are expensive, rigid, and difficult to produce in high yield, and require exotic materials and manufacturing processes for fabrication. DARPA is interested in looking to nature for materials and/or designs that can be incorporated into existing sensor systems to enhance performance or enable new tactics and platform concepts. Biological organisms can sense a multitude of stimuli using highly evolved, often novel structures with unique innervations schemes. For example, insects sense a multifaceted array of stimuli including: moisture, gas/fluid flow, vibrations, pressure, and chemicals, to name a few. This sensing process is of interest to DARPA because of the high sensitivity these systems possess and the fact they do this without the need for silicon micromachining - the technology of choice for man-made sensor systems. From a materials perspective, we are interested in how organic/polymeric materials are accomplishing the same task sensor designers accomplish with inorganic composites. Often, biology uses composite materials systems composed of various materials that differ in their properties commensurate with their function in the sensory system. Using techniques including biochemical characterization, microscopy, and molecular biology, one can characterize the unique biological material systems that allow a particular sensing activity to occur. DARPA is interested in characterizing, synthesizing, and fabricating these material systems and combining these materials with state-of-the-art materials science approaches to device microfabrication. There are a number of potential users and benefactors of this technology. Low-cost, "disposable" sensor technology has many applications in the military as well as commercial world. Bio-inspiration is key to driving the low cost revolution in sensor technology. Potential operational concepts should include a transition path to potential unmanned air, marine, and ground vehicle customers.

PHASE I: Demonstrate the feasibility of a bio-inspired or bio-derived sensor system. The proposed materials system must be able to be incorporated into lightweight, room temperature sensors. Phase I shall include or incorporate, by reference data, the environmental robustness qualities of the materials system.

PHASE II: Incorporate the sensor materials system into at least two detection or imaging systems. The offeror shall demonstrate and test the performance and utility of the materials systems to include, but not limited to, factors to quantify the sensitivity, stability, and processing repeatability qualities of the materials system. The deliverables from Phase II should include demonstration quantities of the materials system, the performance and test data, and the final report.

PHASE III Dual Use Applications: Successful development of a bio-inspired sensor technology has virtually limitless applications in the military and commercial marketplace. Law enforcement, medical imaging, security, recreational, and automotive applications are only a few of the numerous options.

REFERENCES:
1. Jack Chen, Zhifang Fan, Jun Zou, Jonathan Engel, and Chang Liu. "Two-Dimensional Micromachined Flow Sensor Array for Fluid Mechanics Studies," Journal of Aerospace Engineering 16: 85-97 (2003).
2. Helmut Schmitz, Anke Schmitz, Stefan Trenner, Horst Bleckmann. "A new type of insect infrared organ of low thermal mass," Naturwissenschaften 89: 226-229 (2002).
3. Peter G. Gillespie and Richard G. Walker. "Molecular basis of mechanosensory transduction," Nature 413: 194-202 (2001).

KEYWORDS: Bio-Inspired, Bio-Derived, Insect-Inspired, Polymeric MEMS, Sensors.

SB043-040 TITLE: Deductive Spreadsheets

TECHNOLOGY AREAS: Information Systems, Human Systems

Topic falls within the International Traffic in Arms Regulations

OBJECTIVE: To develop an extensible, logic programming environment for military and civilian decision makers.

DESCRIPTION: One of the most useful and pervasive computing tools today is the spreadsheet. Novices and power users alike are able to use this flexible tool to do everything from performing simple arithmetic to programming complex financial analyses. We would like to develop an analogous tool for logical reasoning—a "deductive spreadsheet" that would allow users to define logic statements and inference rules for symbolic reasoning in the same way that current spreadsheet allow users to define mathematical formulae for numerical calculations. Such a tool could provide users with a powerful reasoning tool to capture decision rules, to perform "what if" analyses, and to translate and transform symbolic data from one form to another. The basic idea would be to develop the right spreadsheet-like user interface to put on top of a logic programming environment that would allow users to easily define logic statements and inference rules for automatic inference and decision support.

PHASE I: Conduct a feasibility study for a Deductive Spreadsheet system; suggest a logic programming environment and a design to analyze possible user interfaces.

PHASE II: Develop a prototype Deductive Spreadsheet system and test the prototype with users to discover the most effective and useful user interface for user acceptance.

PHASE III Dual Use Applications: Military and commercial decision makers share the need for reasoning aids to help with complex decisions they make everyday. A logical reasoning tool—if easy enough to use—could be an invaluable aid in capturing decision rules and performing "what if" analyses of new and changing situations. Such a Deductive Spreadsheet tool could be used by military planners to capture standard operating procedures, rules of engagement, logistics procedures, and a wide range of decision rules. It could be used by business mangers to capture business rules, operating procedures, and decision rules. If successfully developed, this tool could become a ubiquitous part of everyone's computing environment.

KEYWORDS: Reasoning, Decision Aids, Logic Programming, Deductive Inference.

SB043-041 TITLE: Tactical Group Decision Analysis Support System

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Identify and develop innovative technology to enable, at tactical timescales, distributed group decision analysis and subsequent monitoring.

DESCRIPTION: Decision analysis is a discipline that involves systematic quantitative techniques for making better decisions [1]. Decision analysts distinguish between good decisions and good outcomes; a good decision is the one that maximizes the probability of a good outcome in light of everything that is known at the time of the decision. The mechanisms of decision analysis are varied: an understanding of stakeholder goals can be represented with structures such as utility functions and value trees; the structure of a problem can be captured and iteratively refined with representations such as influence diagrams; and ultimately techniques such as sensitivity analysis and value-of-information exercises help decision-makers focus attention on the most critical relevant factors. Group decision analysis, sometimes called "decision conferencing", extends the benefits of decision analysis by serving as a process for obtaining group consensus, developing stakeholder commitment, and leveraging organizational knowledge.

Group decision analysis is difficult to conduct and use in tactical (real-time, high-pressure) situations given the state of the art. Participants ordinarily meet in a single physical location. An expert facilitator is usually needed to translate layman input into sophisticated underlying formalisms such as influence diagrams. This facilitator serves as a bottleneck and as a source of bias in integrating organizational knowledge into a unified representation. A monolithic unified representation has the drawback that individual contributions to the decision representation are merged and lost; it becomes impossible for a decision-maker/leader to isolate and differentiate problematic inputs and/or restructure the problem representation to match what is sometimes the unique perspective of that leader. The decision analysis process often takes weeks or months (a strategic timescale) instead of minutes or hours (a tactical timescale). And finally, the artifacts of decision analysis are often "write-only", that is to say, those artifacts are not routinely revisited as new information is gathered to trigger re-evaluation of plans formed on the basis of the decision.

The current effort would develop a software system to support group decision analysis in distributed tactical scenarios by combining: (1) novel and useful data structures and algorithms for representing individual contributions to a group decision analysis, and controlling the merging of those individual contributions into a consensus representation under the editorship of the decision-maker; (2) novel distributed infrastructure and user interface mechanisms to support real-time group decision analysis without the need for an expert facilitator, and moreover without any need for the participants to be in the same place at the same time; and (3) mechanisms that support continuous tracking of real-world events and stakeholder revisions related to the decision so that it can be revisited when events indicate that the decision that has been taken is no longer optimal.

PHASE I: Conduct a feasibility study on a system design that includes specification of group decision analysis formalisms, user interface design, and distributed system to support distributed (non-face-to-face) group decision support without the need for an expert facilitator. Characterize the kinds of decisions and scenarios that are supported with the technology and argue that both tactical as well as the more strategic decision-making timelines are supported. Characterize the scalability of the algorithms and overall system. Characterize the network requirements needed to support a distributed group analysis session. Argue that the system could be applied in a realistic environment.

PHASE II: Develop and demonstrate a prototype system in a realistic environment.

PHASE III Dual Use Applications: This system could be used in a broad range of military and civilian decision analysis scenarios including both strategic and tactical decision-making (see [1] for references to strategic examples in the literature). For example: in emergency response situations it might be possible to formulate and analyze decision problems very rapidly across organizations and automatically monitor the need to revisit those decisions; when confronted with attacks or outages in public infrastructure (telecommunication, power, etc) it might be possible for administrators to formulate tactical responses based on group decision analysis across a variety of stakeholder organizations; and in battlefield situations with rapidly evolving situational knowledge it might be possible to formulate and monitor battlefield decisions rapidly in ways that efficiently exploit full organizational knowledge.

REFERENCES:
1. Decisions Analysis Applications in the Operations Research Literature, 1990-1999. Keefer, D.L. and Corner, J.L. and Kirkwood, C.W. July 2000.
http://www.public.asu.edu/~kirkwood/Papers/DAAppsSummaryTechReport.pdf.

KEYWORDS: Decision Analysis, Decision Support Systems, Group Decision Support Systems, Sensitivity Analysis, Value-of-Information Analysis, Probability Elicitation, Decision Conferencing, Multiattribute Analysis, Value Trees, Decision Trees, Influence Diagrams.

SB043-042 TITLE: Adaptive Command and Collaboration

TECHNOLOGY AREAS: Information Systems, Electronics, Battlespace, Human Systems

OBJECTIVE: Design and prototype a set of collaboration tools that provide commanders the capability to rapidly and optimally form ad hoc teams based on observed red (enemy) and blue (friendly) behaviors.

DESCRIPTION: Current task organizations in the ground combat environment are established to support the commander's operational plans. The time required to create and promulgate the necessary blue team relationships can often exceed the period with which the red forces can present new situations. On a more micro scale, the creation of staff teams within a command organization to address specific critical information needs is often done without complete knowledge of who possesses the requisite expertise or domain knowledge. Tools that can discover and index combat units capability and individual staff member's expertise are needed so that the commander and his staff do not have to continually maintain online descriptions of capability. The desire is to create tools that can unobtrusively monitor behavior (both field performance and topical communication) over multiple epochs and can suggest aggregation(s) of capability to suit particular situational or informational needs.

PHASE I: Identify basic behavior and communication observables and map them to the capability/expertise space. Prepare a feasibility study for a design system that will allow a commander to rapidly aggregate or query on the new space.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III Dual Use Applications: This system could be used in a broad range of civilian rapid team formation activities such as emergency response or special event planning.

REFERENCES:
1. Peter Gray, The Effects of Knowledge Management Systems On Emergent Teams: Towards a Research Model, Journal of Strategic Information Systems, 2000.
2. Tom DeMarco: Non-Technological Issues in Software Engineering. ICSE 1991: 149-150.
3. Gary Illingworth. "Command, Control (C2) and Coalition Interoperability Post '911': Introducing the Network Centric Infrastructure for Command Control and Intelligence (NICCI)". http://www.dodccrp.org/Activities/Symposia/2002CCRTS/Proceedings/Tracks/pdf/073.PDF.

KEYWORDS: Command and Control, Collaboration, Adaptive Team Formation.

SB043-043 TITLE: RF Time of Flight Ranging Techniques for Self-Localization of Microsensors

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Identify and develop innovative technologies to enable radio frequency (RF) time of flight (ToF) ranging between microsensors that are restricted in power and computation.

DESCRIPTION: The exploitation of wireless sensor networks very often requires knowledge of the location of each device within the network. Current technologies have advanced the processing power and communications range of devices that a network may consist of a large number of nodes (possibly hundreds of thousands) deployed over a large area (possibly tens of square miles). A deployment with this type magnitude would support operations in wide-area surveillance, tracking of activity, and the detection and classification of assets. An accurate method of determining each node's precise location within the network significantly improves the accuracy of data collected by the sensor network. This capability supports an ad-hoc deployment of nodes (eliminating the need to deploy nodes to precisely known locations) and reduces the need to "touch" each node once deployed. Additionally, this capability allows wireless sensor networks to recalibrate the location of nodes when they are moved or repositioned.

One method for determining each node's precise location utilizes time of flight (ToF) data collected for radio frequency (RF) communications between nodes. This effort would involve the development of methods to estimate distances between nodes by measuring the arrival time difference of RF signals with different propagation speeds. This method would allow each node to use the distance between it and its "neighbors", as well as each "neighbor's" position, to compute its own position. Of special importance is the ability to do this in an energy-constrained node which may not be able to do a significant amount of processing.

PHASE I: Conduct a feasibility study on time of flight ranging techniques that utilize radio frequency communications data. Identify those techniques that may be beneficial to large-scale deployments of wireless sensor networks.

PHASE II: Develop a prototype ToF ranging system (algorithms, software, hardware, communications) and demonstrate its use in an operationally-realistic environment. Conduct testing and evaluation of the system to prove its effectiveness to accurately determine the absolute position of nodes within a wireless sensor network.

PHASE III Dual Use Applications: This technology has both military and commercial applications for wireless sensor networks. For military use, it will increase the ability to deploy wireless sensor networks without putting warfighters or other assets in danger. For commercial use, it will reduce the time required to deploy and wireless sensor networks and maintain them once deployed.

KEYWORDS: Time of Flight, ToF, Radio Frequency, RF, Wireless Sensor Networks.

SB043-044 TITLE: Narrow-Linewidth 1550 Nanometer Laser Oscillator

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

OBJECTIVE: The development of a long coherence length, single frequency low noise laser source in the eye-safe 1550 nanometer (nm) wavelength range.

DESCRIPTION: Presently, distributed feedback (DFB) semiconductor lasers are limited to 0.1 to 1 MHz linewidths, 50 milliwatt (mW) output powers and –160 decibels (dBc) relative intensity noise (RIN) levels. This performance, while adequate for telecommunication systems, is inadequate for many DoD photonic systems. Many DoD applications benefit from coherent detection and processing techniques which require laser linewidths at or below the 1 kHz range and low laser RIN yielding shot noise limited performance at high photocurrents. Additionally, radio frequency (RF) photonic systems benefit from low-noise high power lasers and interferometric fiber optic sensor systems benefit from low phase noise for increased sensitivity limits and lower fabrication tolerances (high cost). Thus the need for high coherence, low noise 1550 nm laser sources which will benefit a wide range of DoD applications. The most significant challenges for a single mode 1550 nm laser are: linewidths less than 1 kHz, output powers greater than 100 mW, laser mode spacing greater than 20 GHz, side mode suppression ratio greater than 60 dB, operating wavelength between 1545 and 1560 nm, relative intensity noise below –170 dBc/Hz from 0.1 to 100 GHz, low production cost and robust environmental stability. Laser mode spacing smaller than 20 GHz is acceptable if the side mode suppression ratio increases to over 80 dB. Innovative laser research and development is solicited that addresses this critical need. Diode-pumped fiber and solid-state lasers, as well as innovative external cavity semiconductor laser diode designs are considered prime candidates for meeting the aggressive laser performance specifications stated above.

PHASE I: Prepare a feasibility study of a laser design which can be analyzed and evaluated in detail. It would be desirable for the study to include a proposed demonstration which would include calculations to support how the design would scale to meet the desired performance specifications.

PHASE II: Development of a proof-of-principle laser prototype with performance tests to access the ability of the design to meet the above technical challenging specifications. Initial packaging considerations must also be addressed at this time to ensure that the design will be robust.

PHASE III Dual Use Applications: A pre-production prototype would be used in several system demonstrations to access overall performance. There are several commercial telecommunication, medical and LIDAR applications that could also benefit from this development. Coherent imaging offers higher resolution than conventional imaging techniques which is critical in many non-intrusive medical applications. Coherent signal transmission offers higher detection sensitivity which is critical for commercial fiber and free space communications and LIDAR applications. As more affordable highly coherent optical oscillators become available, many more commercial networking and sensing applications will begin to surface.

REFERENCES:

1. "230-mW Diode-Pumped Single-Frequency Er:Yb Laser at 1.5 µm," S. Taccheo, G. Sorbello, et al, IEEE Photon. Technol. Lett., Vol. 13, pg. 19-21, 2001.
2. "166-mW Single Frequency Output Power Interactive Fiber Lasers with Low Noise," J. Pan and Y. Shi, IEEE Photon. Technol. Lett., Vol. 11, pg. 36-38, 1999.
3. "High Power Single-Frequency Narrow-Linewidth Erbium-Doped Fiber Laser," Y. Hu, C. Spiegelberg et al, IEEE LEOS Annual Meeting 2003, pg. 794-795, 2003.
4. " A 1.55-µm Solid-State Laser Source for DWDM Applications," T. Boyd, D. Klemer, et al, Journal of Lightwave Technol., Vol. 17, pg. 27-33, 1993.

KEYWORDS: Laser, Microwave Photonics, LIDAR, Optical Fiber Sensors, Electronic Warfare, Fiber Optics, Coherent Optical Communications.

SB043-045 TITLE: Nano-Imprint Mask Technology

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: To establish a viable method of cost-effectively producing imprint mask molds with sub 45 nanometer (nm) pitch features, and demonstrate transfer of nanoscale features to semiconductors.

DESCRIPTION: Imprint lithography is receiving consideration as a potential next-generation lithography technology. It is often referred to as Nano-Imprint Lithography at the dimensional scale of interest here, namely 45 nm and below. Nano-Imprint Lithography consists of an actual size mold or template that usually has topographical features that are pressed onto a polymer coating over the semiconductor wafer. Various processes are used to assist in the transfer of the mold pattern to the polymer, such as a thermal cycle or exposure to ultraviolet radiation. In a well controlled process, the exact inverse of the mold is transferred to the polymer coating. One of the difficult challenges for this technology is that the masks must be actual size; there is no reduction as in an optical stepper. This topic seeks innovative methods of creating imprint masks consistent with dense, sub 45nm features and low line edge roughness, less than 5% rms. The methods should be cost-effective; scalable to large wafers and smallest possible features; and capable of producing arbitrary and dense patterns. In addition, the resulting masks or templates should be compatible with imprint tools. Innovations in all aspects of mold and template fabrication are needed, including, but not limited to, subtractive processes, additive processes, directed assembly of features, advanced coatings, and micro-machining processes. Also of interest are methods to achieve a high degree of alignment and overlay between subsequent masks. In addition, this topic seeks innovative methods to inspect, correct, and otherwise repair nano-imprint masks.

PHASE I: Determine the feasibility of developing the mask/template fabrication technology for sub 45 nm features through experiments, simulations, analyses, or other studies, and develop appropriate metrics. Perform a study of the expected costs associated with the approach as a function of volume, and other parameters as appropriate that describes the technology.

PHASE II: Implement the mask/template fabrication process and produce a working set of masks or templates for sub 45nm transistor type device or test circuit fabrication. Perform experiments to determine the major cost factors in imprint mask fabrication and develop strategies for reducing costs under low wafer volumes.

PHASE III Dual Use Applications: Nano-Imprint Lithography is inherently a dual use technology. Military product volumes are typically small, and this technology will serve that niche cost-effectively. In addition, commercial prototyping and engineering samples are also usually low in volume but need very short turn-around times. Nano-imprint technology may have great application in meeting both needs for fast turnaround of high quality masks for deeply scaled integrated circuits.

REFERENCES:
1. http://public.itrs.net, "The International Roadmap for Semiconductors," 2003.
2. http://www.nntconf.org/pdf/2003_NNT_Program.pdf,
"Proceedings of the Second International Conference on Nanoimprint and Nanoprint Technology," Boston, December 2002.

KEYWORDS: Nano-Imprint, Nanoimprint, Nanoprint, Masks.

SB043-046 TITLE: Advanced, Regenerable Chemical and Biological Filters

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: Develop revolutionary air filtration technology that both captures and neutralizes chemical and biological agents with high efficiency and low resistance to airflow. The technology must have higher capture efficiency, longer lifetime, and lower pressure drop then current state-of-the-art approaches. Furthermore, capability to scale the technology from large systems, for building protection, to miniaturized capability, for personal protective equipment is a key objective.

DESCRIPTION: Recent releases of chemical and biological weapons have increased the urgency to develop and integrate better protective equipment to defend military personnel, emergency responders, and the public from these escalating threats. Current nuclear, biological and chemical (NBC) filters are effective in trapping airborne pathogens and classical chemical weapons but suffer the deficiencies of relatively high weight and bulkiness, high resistance to airflow, limited capacity and lifetime, inefficiency against some toxic industrial chemicals, and the release of previously captured agents from the filter under hot or humid conditions.

Thus, there is an urgent need for revolutionary filtration technologies to dramatically improve the protective capabilities of NBC filters. Specifically, the target filter will capture 99.99+% of 1-10 micron particles while exhibiting less than 25% of the airflow resistance of a high efficiency particulate air (HEPA) filter. The filter must incorporate new technology, for example, the capability to inactivate a broad range of chemical and/or biological threats with high capacity. It is highly desirable for the filter to be self-cleaning and regenerable to maximize the time between filter changes. Preferably, the filter will neutralize chemical and biological weapons to prevent the re-release of agents upon removal of the filter or changes in atmospheric conditions. Furthermore, the filter must be scalable to address all key protection requirements.

PHASE I: Develop a methodology for a highly efficient, long-lived filtration system for the capture and neutralization of a broad range of chemical and biological agents. Prepare a feasibility study to show performance advantages over current NBC and HEPA filtration technologies.

PHASE II: Develop the novel filtration technology and characterize the filter performance including the capture efficiency for bio-aerosols and the breakthrough times for chemical weapon analogs. Incorporate the technology into a compact filter suitable for testing with live agents at Government selected facilities.

PHASE III Dual Use Applications: The resulting technology will have significant carry over benefits, including integration into HVAC systems for the protection of military, commercial, and residential building occupants against both chemical/biological terrorism, as well as more common residential hazards such as toxic mold and volatile organic pollutants.

KEYWORDS: Air Filtration, First Responders, Chemical/Biological Warfare/Terrorism Defense.

SB043-047 TITLE: Integrated Wafer Phased-Array Antenna

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and validate an approach to wafer-scale integration of phased-array antenna electronics, focusing on wafer-scale interconnects for radio frequency (RF), direct current (DC), and control signals.

DESCRIPTION: A typical active-array antenna is a planar array of small antenna elements spaced one-half wavelength apart in two dimensions. A typical radiated frequency is 10 GHz which makes the wavelength about 3 cm, the array lattice spacing about 1.5 cm, and the area per element about 2.25 cm2. Behind each element is a "Transmit/Receive (T/R) module" that contains a transmit power amplifier, a receive low noise amplifier, a phase shifter, switches to select between the transmit or receive paths, and control circuitry. The array requires distribution networks to bring power, control signals, and transmit RF signals from a central point to every element in the array, and to collect the received RF signal from every element and combine it into a single signal.

Recent developments at DARPA has integrated all of the T/R module electronics into a single T/R chip (Silicon Germanium (SiGe) Monolithic Microwave Integrated Circuit (MMIC) with integrated digital control). The goal of this SBIR effort is to explore wafer-scale integration at higher frequencies such as 35 GHz. The T/R chip area on the wafer is not much smaller than the 0.18 cm2 area per element as determined by the array lattice spacing. In this approach, the wafer of T/R chips will not be diced. Additional processing steps will be utilized to add interconnects for DC, RF, and control signals to create a single wafer-level interface for each type of signal. Feed vias will be drilled through the wafer at each element location. A dielectric, foam, or honeycomb spacer will be added to the back side, followed by patch-type elements. This integrated wafer may be the entire antenna for a missile seeker. Or, the wafer might serve as a sub-array building block to tile the area of a much larger array. Compared to conventional active array technology, the integrated wafer will offer advantages in cost, weight, and manufacturing precision.

PHASE I: Develop a feasibility study to complete approach through which a wafer-scale integrated phased-array antenna could be realized. Consideration must be given to the element level electronics, the inter-element connections, external interfaces, packaging, and the operation of the entire wafer as a single system.

PHASE II: Fabricate and test an integrated phased-array wafer or sub-wafer sized array. Testing will probably require RF radiation for system level characterization of the entire array.

PHASE III DUAL USE APPLICATIONS: The technology developed under this effort is directly applicable to phased-array antennas used for radar and communications. The approach offers significant improvement in manufacturing cost, which is highly attractive for commercial applications. The approach also offers significant weight reduction, which is highly attractive for commercial and military space-based applications.

KEYWORDS: MMIC, T/R Module, Phased-Array, Antenna.

SB043-048 TITLE: UAV Survivability Enhancement via Agile Maneuvering in Dynamic Environments

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Electronics, Weapons

OBJECTIVE: Design and develop a fixed wing or rotary wing air vehicle that can implement agile maneuvering control and software algorithms using optic flow data to avoid static and dynamic obstacles.

DESCRIPTION: Inner-loop control for highly aggressive (in the non-linear sense) maneuvers is a recently matured technology. The combination of discrete maneuvers into trajectories constrained by vehicle dynamics is entitled "kinodynamic planning" or simply maneuver. Typically, trajectory planning is driven by a mission planning layer – the rudimentary equivalent of on-board cognition. In recent years, several approaches to dynamic mission planning have been proposed. One is based on event trees – constructed dynamically – which are then evaluated in real time using a cost function and a search algorithm (Adams, 2002). Another proposed method uses Markov modeling and game theory to play out possible maneuver sequences against an opponent.

In parallel to these efforts of the aerospace controls community, advances in artificial intelligence and insect vision research has yielded an architecture that successfully replicates basic animal behaviors – such as, for instance, insect flight and navigation. Brooks (1986, 1991) developed a methodology, entitled "subsumption" or "behavioral control," that is based on the interaction of simple behaviors triggered by specific external stimuli. Surprisingly complex and effective behavioral patterns have been observed to emerge. This technique was successfully demonstrated on ground robots. In addition, insect-like navigation and control concepts using optic flow data has been successfully demonstrated on a few air vehicles.

Thus, the relative merits of these various approaches and potential combinations thereof will be the subject of this topic. This study is focused on integrating optic flow sensors with cognitive based dynamic decision and maneuver algorithms on a UAV platform to enhance its survivability.

PHASE I: Systems studies to identify requirements for performance studies to size concepts and identify technology and design requirements. In this early phase a single vehicle concept will be described and simulated using input data from commercially available optical flow sensors.

PHASE II: A target application will be identified. A proof-of-concept model for this application will be designed and constructed for limited demonstration. This model need only be sized and constructed in a manner that provides a realistic demonstration that will justify future investment.

PHASE III Dual Use Applications: There are a number of military and commercial applications to increase the survivability of manned and unmanned assets. In the military sector an agile maneuvering air vehicle that uses optic flow data could enable a vehicle to avoid obstacles such as buildings and trees, as well as moving objects such as other air vehicles. Such a capability may also enable a UAV to avoid attacks from rocket propelled grenades and small arms fire. Civilian applications include the use of such algorithms to avoid hazards for commercial aircraft such as mountains and other aircraft.

REFERENCES:
1. Adams, M. et al, "Mixed Initiative Planning and Control Under Uncertainty", AIAA-2002-3452, Presented at the AIAA Guidance and Control Conference, 2002.
2. McConley, M., Appleby, B. et al., "Hybrid Control for Aggressive Maneuvering of Autonomous Aerial Vehicles", Digital Avionics System Conference, 2000.
3. Brooks, R., 1986, "A Robust Layered Control System for a Mobile Robot", IEEE Journal of Robotics and Automation, Vol. 2, No. 1, pp. 14-23.
4. Brooks, R., 1991, "Intelligence Without Reason", Proceedings of 12th Int. Joint Conf. on Artificial Intelligence, Sydney, Australia, pp. 569–595.
5. Frazzoli, E., Dahleh, M., Feron, E., 2002, "Real-Time Motion Planning for Agile Autonomous Vehicles", AIAA Journal of Guidance, Control, and Dynamics, 25(1): 116-129.
6. Gavrilets, V. et al., 2002, "Control Logic for Automated Aerobatic Flight of a Miniature Helicopter", AIAA Guidance, Navigation, and Control Conference, Monterey, CA.
7. Hauser, J., 1997, "Aggressive Flight Maneuvers", Proceedings of the 26th IEEE Control & Dynamics Conference, San Diego, CA.
8. Parker, L., 1995, L-ALLIANCE: A Mechanism for Adaptive Action Selection in Heterogeneous Multi-Robot Teams, TM-13000, Oak Ridge National Laboratory, TN.

KEYWORDS: Agile Maneuvering, Optic Flow, Mission Planning, Survivability, Flight Control.

SB043-049 TITLE: Agile Maneuvering Using Dynamic Control Surface Morphing

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Weapons

OBJECTIVE: Design and develop deployable control surfaces that can exploit innovative adaptive and morphing structures technology at minimal cost and weight to achieve highly maneuverable munitions that can be retasked to achieve new mission objectives.

DESCRIPTION: Munitions often deployed on ballistic trajectories toward their targets with considerable accuracy. However, they cannot be retasked to strike other targets of opportunity while enroute. To be able to respond to dynamic re-planning, there are several enabling technologies required to retask a munition to achieve a new mission objective. These include a guidance and navigation package, a communications link and adaptive control surface capability to provide an agile maneuvering capability to avoid obstacles. Recent advances in steady and unsteady aerodynamics, and adaptive/morphing structures actuator technology including the development of compact hybrid actuators, electroactive polymers, thin film magnetic shape memory alloys, microjets and the emergence of solid state multifunctionality in aerodynamic structures may contribute to highly maneuverable munitions that can enhance system survivability and functionality. There is a need to augment existing munitions with enhanced flight control functionality to allow for agile maneuvering. Enhancements in flight control capability must be achievable in milliseconds and be capable of providing an order of magnitude in control capability. This may be achievable with large scale geometric shape changes in the munition's control surface or through effective management of aerodynamic flow over the munition's shape to provide effective steering capability.

Finally, to achieve truly robust agile maneuver capability, enhanced flight control functionality must be combined with recent advances in cognitive decision and dynamic planning techniques to efficiently retask a munition to achieve a new mission. The focus of this study, however, will be on the system integration of enhanced flight control functionality to a suite of munitions using innovative adaptive and morphing structures technology.

PHASE I: Systems studies to identify requirements for a suite of munitions in the 120mm to 150mm class of munitions including rocket propelled grenades. Conduct trade studies to evaluate various concepts against performance metrics such as weight, response time, power, enhanced flight envelope capability, cost and reliability. In this early phase a number of deployable control surface concepts will be described and compared. An additional metric of interest include the ability control surface concept to to existing munitions.

PHASE II: A proof of flight control enhancement concept model will be designed and constructed for limited demonstration including wind tunnel and flight experiments. This model need only be sized and constructed in a manner that provides a realistic demonstration that will justify future investment.

PHASE III Dual Use Applications: There are a number of military and commercial applications to increase the maneuverability of the Army's munitions. In the military sector an agile maneuvering munition can be retasked to achieve complex missions. Civilian applications of such technology include UAVs, light aircraft and the hobby aircraft community.

REFERENCES:
1. Marx, W.J., et. al., "Miniature Smart Munitions/Guided Projectiles for the Objective Force", 23rd Army Science Conference, December, 2-5, 2002, Orlando Florida.
2. Mattice, M., Frampton, K., "Smart Materials and Structures for Multi-Role FCS Ammo Suite", 6th International Cannon Artillery Firepower Symposium & Exhibition, June, 2000.

KEYWORDS: Smart Materials, Morphing, Flight Control, Mission Planning, Maneuver.