DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY2010.3 SBIR Proposal Submission

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

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

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

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

SPECIFIC DARPA REQUIREMENTS:

2.15 Foreign National

DARPA topics are unclassified; however, the subject matter may be considered to be a "critical technology" and may be subject to ITAR restrictions. If you plan to employ NON-U.S. Citizens in the performance of a DARPA SBIR contract, please inform the Contracting Officer who is negotiating your contract. See **Export Control** requirements below in Section 5.

3.5 Phase I Proposal Format

PHASE I OPTION

PHASE I OPTION MUST BE INCLUDED AS PART OF PHASE I PROPOSAL. DARPA has implemented the use of a Phase I Option that may be exercised to fund interim Phase I activities while a Phase II contract is being negotiated. Only Phase I companies selected for Phase II will be eligible to exercise the Phase I Option. The Phase I Option, which must be included as part of the Phase I proposal, covers activities over a period of up to four months and should describe appropriate initial Phase II activities that may lead to the successful demonstration of a product or technology. The Phase I Option must be included within the 25-page limit for the Phase I proposal.

A Phase I Cost Proposal ($149,000 maximum) must be submitted in detail online. Proposers that participate in this Solicitation must complete the Phase I Cost Proposal, not to exceed the maximum dollar amount of $99,000, and a Phase I Option Cost Proposal (if applicable), not to exceed the maximum dollar amount of $50,000. Phase I and Phase I Option costs must be shown separately but may be presented side-by-side on a single Cost Proposal. The Cost Proposal DOES NOT count toward the 25-page Phase I proposal limitation. Phase I awards and options are subject to the availability of funds.

3.7 Phase II Proposal Format

DARPA Program Managers may invite Phase I performers to submit a Phase II proposal based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3 of the SBIR 10.3 solicitation. Phase II proposals will be evaluated in accordance with the evaluation criteria provided in Section 4.3. Due to limited funding, DARPA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

PHASE II OPTION

PHASE II OPTION MUST BE INCLUDED AS PART OF PHASE II PROPOSAL. DARPA has implemented the use of a Phase II Option that may be exercised at the DARPA Program Manager's discretion to continue funding Phase II activities that will further mature the technology for insertion into a larger DARPA Program or DoD Acquisition Program. The Phase II Option, which must be included as part of the Phase II proposal, covers activities over a period of up to 24 months and should describe Phase II activities that may lead to the successful demonstration of a product or technology. The Phase II Option must be included within the 40-page limit for the Phase II proposal.

A Phase II Cost Proposal ($1,000,000 maximum) must be submitted in detail online. Proposers that submit a Phase II proposal must complete the Phase II Cost Proposal, not to exceed the maximum dollar amount of $1,000,000, and a Phase II Option Cost Proposal (if applicable), not to exceed the maximum dollar amount of $750,000. Phase II and Phase II Option costs must be shown separately but may be presented side-by-side on a single Cost Proposal. The Cost Proposal DOES NOT count toward the 40-page Phase II proposal limitation. Phase II awards and options are subject to the availability of funds.

If selected, the government may elect not to include the option in the negotiated contract.

4.0 Method of Selection and Evaluation Criteria

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

4.2 Evaluation Criteria

In Phase I, DARPA will select proposals for funding based on the evaluation criteria contained in Section 4.2 of the DoD solicitation, including potential benefit to DARPA, in assessing and selecting for award those proposals offering the best value to the Government.

DARPA will use the Phase II Evaluation criteria in Section 4.3 of the DoD solicitation, including potential benefit to DARPA and ability to transition the technology into an identified system, in assessing and selecting for award those proposals offering the best value to the Government.

As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be of superior 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 quality of the proposals is deemed superior and are highly relevant to the DARPA mission, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

4.4 Assessing Commercial Potential of Proposals

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

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

4.5 SBIR Fast Track

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

4.6 Phase II Enhancement Policy

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

4.7 Commercialization Pilot Program

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

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

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

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

- Success Reports: The Foundation will document company Phase III transition successes individualized reports as well as or other printed material for distribution at outreach events and for posting on the DARPA SBPO Web site. SBIR companies that have received Phase III funding are eligible to work with The Foundation to develop the success report. Cleared Success Reports will continue to be posted on the DARPA SBPO Web site. The 2007 DARPA SBIR Success Reports can be viewed at this link: http://www.darpa.mil/sbpo/success/index.html

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

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

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

- DARPA Phase I awards will be Firm Fixed Price contracts.
- Companies that choose to collaborate with a University must highlight the research that is being performed by the University and verify that the work is FUNDAMENTAL RESEARCH.
- Companies are strongly encouraged to pursue implementing a government acceptable cost accounting system during the Phase I project to avoid delay in receiving a Phase II award. Visit www.dcaa.mil and download the "Information for Contractors" guide for more information.

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

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

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

- DARPA Phase II awards are typically Cost Plus Fixed Fee contracts; however, DARPA may choose to award a Firm Fixed Price Phase II contract or an Other Transaction (OT) on a case-by-case basis. Visit http://www.darpa.mil/sbpo/ot/index.html for more information on Other Transactions.
- Companies are advised to continue pursuit of implementation of a government acceptable cost accounting system in order to facilitate their eligibility for future government contracts.
- Companies that choose to collaborate with a University must highlight the research that is being performed by the University and verify that the work is FUNDAMENTAL RESEARCH.

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

DARPA Phase II proposals should be structured as a 24 month effort in two equal increments of approximately $500,000 each. The entire Phase II base effort should generally not exceed $1,000,000.

5.3 Phase I Report

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

5.11.r. Export Control

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

(1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

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

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

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

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

5.14.h. Human and/or Animal Use

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

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

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

6.3 Notification of Proposal Receipt

DARPA will send each offeror an e-mail acknowledging receipt of proposal after the solicitation closing date.

6.4 Information on Proposal Status

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

6.5 Debriefing of Unsuccessful Offerors

DARPA will provide each unsuccessful offeror an automatic debriefing summary as an enclosure to the notification of non-selection. Requests for clarification to information provided in the debriefing summary must be sent via e-mail to sbir@darpa.mil within 15 days of receipt of notification.

DARPA SBIR 10.3 Topic Index

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DARPA SBIR 10.3 Topic Descriptions

SB103-001 TITLE: Low Noise, High Efficiency Hydraulics for Mobile Robots

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate a novel hydraulic actuation system (including pump, control, and actuator) for use in mobile robots that achieves noise and efficiency performance superior to that obtainable with current systems.

DESCRIPTION: Hydraulic actuation has been successfully used in industrial robots for decades, and in a few mobile robots. Hydraulic systems are typically advantageous compared to other actuation systems in their power density and force density. However, making use of hydraulics in mobile robotic systems poses formidable challenges, particularly in energy efficiency and noise. DARPA seeks to develop improved energy efficiency and lower noise hydraulic actuation systems for mobile robots without significant sacrifices in other performance parameters (such as bandwidth, force density, power density, range of motion, accuracy, etc.).

PHASE I: Develop a conceptual design for a quiet, highly energy efficient hydraulic actuator system (including pump, control, and actuator) targeted for use on small to medium sized mobile robots (from the size of a small dog to the size of a man). Develop a robust methodology for testing and reporting attained effectiveness in noise and efficiency.

Test key hypotheses by developing, constructing, and testing prototype subsystems. Deliverables should include a detailed design document containing specifications for the physical components, sensors, and software design and a final Phase I report that includes: (1) a review of the design based on criteria specified in the description, (2) a high level comparison of existing research and alternative approaches, and (3) a Phase II plan.

PHASE II: Design and build a quiet, highly energy efficient hydraulic actuation system (including pump, control, and actuator) that could be integrated into an existing or prototype robot. The hydraulic actuation system can be applied to mobility, manipulation, or both, as appropriate, to highlight the benefits of the proposed technology. Perform experiments in a laboratory environment and measure results based on the testing methodology as designed and approved during Phase I.

Required Deliverables will include: The prototype system, demonstration and testing of the prototype system, and a Final Report. The Final Report will include (1) a detailed design of the actuation system, (2) experimental results, and (3) a plan for Phase III. It is expected that TRL Level 4 should be reached at the conclusion of the Phase II effort.

PHASE III: Apply the hydraulic actuation technology developed under this effort to existing military robots, for example in the LS3 legged robot, stronger arms for the Packbot and Talon, exoskeleton suits, the remote manipulator arm on the Buffalo mine protected vehicle, etc. It is expected that the hydraulic actuation technology developed under this effort can have numerous commercial and military applications if integrated into a new generation of military and civilian robots.

REFERENCES:

1. Hydraulic Control Systems, Noah Manning, Wiley, 2005.

2. Hydraulics and Pneumatics, Andrew Parr, Butterworth-Heinemann, March 1999.

3. Industrial Hydraulics Manual, Eaton Hydraulics Training Services, 5th edition, 2nd printing, April 2008.

KEYWORDS: Hydraulic Actuation

SB103-002 TITLE: Robot Fabrication via Layered Manufacturing

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Identify and enhance layered fabrication techniques and design tools to enable parallel manufacturing of complex mechanical systems at low cost. Address design tool issues associated with design of robots constructed using this technology.

DESCRIPTION: Existing small robot systems are manufactured in a serial fashion from many parts. By contrast, biological systems are built in parallel, with nearly exponential growth as cells divide and self-assemble. Building artificial systems to replicate biology is not immediately practical, but 2-D printing processes followed by layered assembly of sheets may offer an intermediate solution that will drastically lower the cost of fabricating robots while bringing achievable complexity closer to that of biological systems. Printing processes have already demonstrated their utility in electronics, with a shift from point-to-point wiring to circuit boards to integrated circuits. DARPA seeks an analogous development of layered electro-mechanical components in the fabrication of robots.

Existing robots have structural components, actuators, sensors, communication systems and electronic controls. DARPA seeks a fabrication system that incorporates at least several of these component types into an integrated, layered printing and sheet assembly process directly coupled to conventional 3-D, CAD-based design.

PHASE I: Identify concepts and design fabrication methods that exploit an understanding of the nature and difficulty of low-cost, layered fabrication of highly complex and differentiated components. It is anticipated that the approaches developed will be informed primarily by materials science and fabrication techniques. Describe how eventual maturity and initial feasibility of these concepts might be evaluated and demonstrated and estimate what realistic goals might be established for Phase II of this SBIR. Phase I deliverables should include the conclusions reached, alternatives explored, initial designs, and if possible initial demonstrations of the feasibility of the proposed concepts, as well as a plan for the execution of Phase II.

PHASE II: Construct one or more prototypes that demonstrate the attained level of technical maturity of the processes designed during the Phase I effort. Establish performance parameters through testing in a laboratory environment. The deliverable should also include a final report that describes the fabrication process, the fabricated component, and assesses the ultimate feasibility of the proposed concept/s and their ultimate contribution to the overall objective.

PHASE III: Apply the results of phase II to the fabrication of a militarily useful robot. If a viable application emerges from this research, it is likely to have wide commercial application beyond robotics. It is likely that the result of Phase II would have to reach at least TRL 4 in order for further support or commercialization to occur. At this point, it is difficult to predict what product might emerge.

REFERENCES:
1. PROTOTYPING MILLIROBOTS USING DEXTROUS MICROASSEMBLY AND FOLDING, E. Shimada, J.A. Thompson, J. Yan, R. Wood and R.S. Fearing, Proc. ASME IMECE/DSCD, November 5-10, 2000, Orlando, Florida.

KEYWORDS: Layered fabrication, Segmented design, adhesive bonding, bonding process, computer aided design, computer numeric control, fabrication, manufacturing process

SB103-003 TITLE: Global Intelligence, Surveillance, and Reconnaissance (ISR)

TECHNOLOGY AREAS: Sensors

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: Create an integrated approach to global ISR that enables automated multi-INT exploitation and cross-cueing for a wide variety of missions. Areas of interest include techniques for sensor data alignment, correlation, fusion, and information extraction; detection, identification, and tracking of threat dismounts and vehicles in high volumes of clutter; behavioral modeling and anomaly detection to enable understanding normal patterns and to detect deviations characteristic of activities involving individual adversaries and insurgent networks; integrated and automated human-machine processing, exploitation, and control; and approaches to sensor data processing, exploitation, and understanding that leverage the complementary strengths of humans and machines.

DESCRIPTION: Traditional approaches to ISR system development result in stove-piped sensing-exploitation-visualization systems, as the sensor, its associated exploitation system, and its user interface are developed and tested under conditions representative of the intended missions. This makes sense from the standpoint of minimizing development costs for each stand-alone system, but it forces significant exploitation software re-work to handle sensor and mission variants. Also, this approach to ISR system development makes interoperability difficult and limits the potential for multi-sensor integration, the result being that we currently have a limited capability for multi-INT exploitation and few tools for automatically combining data from and cross-cueing between multiple sources. Finally, our ISR systems typically are set up to process data in a linear way: the sensor produces data, automated exploitation algorithms operate on the data to produce an output, and human-machine interfaces are used to enable humans to understand the outputs, produce products, make decisions, and issue follow-on tasking. But there is generally no effort to more fully integrate the machine and human processing together to take advantages of the strengths of each, particularly the ability of humans to use context to resolve alternative hypotheses or improve estimates, the ability of machines to prioritize opportunities for humans to provide that feedback, and the ability of machines to use that feedback to modify previous, current, and future processed results. Emerging techniques and improving capabilities for real-time control and high-volume data transport between sensor platforms and ground systems make it possible now to more fully integrate humans and machines in the tasking, processing, and control of all ISR assets and achieve multi-sensor exploitation.

The ultimate goal for future multi-sensor/multi-platform ISR is full automation and control of sensors, sensor processing, and exploitation optimized to satisfy prioritized ISR requirements across an entire theater. Included in this goal are the capabilities to 1) produce a unified global ISR picture, 2) meet prioritized ISR requirements for Warfighters ranging from Soldiers in the field to Combatant Commanders, and 3) minimize the need for human operators to analyze raw sensor data or low-level analysis products.

PHASE I:
Discover, develop and demonstrate new techniques for:
- Sensor data alignment, correlation, fusion, and information extraction;
- Multi-INT exploitation and cross-cueing for a wide variety of missions;
- Detection, identification, and tracking of threat dismounts and vehicles in high volumes of clutter;
- Behavioral modeling and anomaly detection to enable understanding of normal patterns and to detect deviations characteristic of activities involving individual adversaries and insurgent networks;
- Integrated and automated human-machine processing, exploitation, and control that leverage the complementary strengths of humans and machines.

Describe the types of data that would facilitate the development and evaluation of their proposed techniques.

PHASE II: Develop, implement in software, rigorously evaluate, and optimize, using analytic and computational techniques as appropriate, detailed algorithmic approaches and software implementations. Construct a representative model or prototype. Test and validate approaches in a relevant environment using the types of data identified in Phase I and/or new data identified through experiments/testing in Phase II. At the conclusion of Phase II algorithms and software should meet or exceed Transition Readiness Level 6 (System/subsystem model or prototype demonstration in a relevant environment).

PHASE III: Delivery of mature software to targeted military systems is expected. The techniques developed under this topic will have either direct or potential applicability in nearly all sensor integration domains including border/port/homeland security, environmental remote sensing, natural resource exploration, industrial systems monitoring, individual and public health, and other data/sensor-rich settings.

REFERENCES:
1. Cao, H., Wolfson, O., and Trajcevski, G. 2006. Spatio-temporal data reduction with deterministic error bounds. The VLDB Journal 15, 3 (Sep. 2006), 211-228

2. Erwig, M., and Schneider, M. 2002 STQL: A Spatio-Temporal Query Language, Martin Erwig and Markus Schneider. Chapter 6 of Mining Spatio-Temporal Information Systems (eds. R. Ladner, K. Shaw, and M. Abdelguerfi), Kluwer Academic Publishers, 105-126

3. Gubiani, D. and Montanari, A. 2008. A conceptual spatial model supporting topologically-consistent multiple representations. In Proceedings of the 16th ACM SIGSPATIAL international Conference on Advances in Geographic information Systems (Irvine, California, November 05 - 07, 2008). GIS '08. ACM, New York, NY, 1-10.

4. Güting, M., Böhlen , M., Erwig , M., Jensen , N., Lorentzos , N., Nardelli, E., and Schneider , M. 2003 Spatio-Temporal Models and Languages: An Approach Based on Data Types. Chapter 4 of Spatio-Temporal Databases: The CHOROCHRONOS Approach (eds. T. Sellis et al.), Springer Verlag, LNCS 2520, 97-146

5. Jansen, K. and Zhang, H. 2006. An approximation algorithm for scheduling malleable tasks under general precedence constraints. ACM Trans. Algorithms 2, 3 (Jul. 2006), 416-434.

6. Krishnamurthy, R., Li, Y., Raghavan, S., Reiss, F., Vaithyanathan, S., and Zhu, H. 2009. SystemT: a system for declarative information extraction. SIGMOD Rec. 37, 4 (Mar. 2009), 7-13.

7. Leung, L., and Yan, J. 1997. Point-in-Polygon Analysis Under Certainty and Uncertainty. GeoInformatica 1,1 (April 1997), 93-114.

8. Lin, G. and Rajaraman, R. 2007. Approximation algorithms for multiprocessor scheduling under uncertainty. In Proceedings of the Nineteenth Annual ACM

9. Mamoulis, N. 2003. Efficient processing of joins on set-valued attributes. In Proceedings of the 2003 ACM SIGMOD international Conference on Management of Data (San Diego, California, June 09 - 12, 2003). SIGMOD '03. ACM, New York, NY, 157-168.

10. Sarne, D. and Grosz, B. J. 2007. Estimating information value in collaborative multi-agent planning systems. In Proceedings of the 6th international Joint Conference on Autonomous Agents and Multiagent Systems (Honolulu, Hawaii, May 14 - 18, 2007). AAMAS '07. ACM, New York, NY, 1-8.

11. Symposium on Parallel Algorithms and Architectures (San Diego, California, USA, June 09 - 11, 2007). SPAA '07. ACM, New York, NY, 25-34.

KEYWORDS: intelligence, surveillance, reconnaissance, sensor, information, process, detect, track, classify, exploit, correlate, cue

SB103-004 TITLE: <u>Lithography-free Manufacturing of Polymer Photonic Devices</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a low cost, high throughput manufacturing method for both active and passive polymer photonic devices.

DESCRIPTION: The fabrication of current polymer photonic devices heavily relies on conventional photolithography (or e-beam photolithography) and ion-etching. These processes not only add considerable fabrication cost, but also induce rough etching surfaces to the polymer photonic devices, thus causing a significant amount of scattering loss. Recently, we have witnessed escalating progress of various lithography-free fabrication methods for nanoscale structures with high precision on a wide variety of materials, such as microcontact printing (or soft lithography) [1], nano-imprint lithography (NIL) [2], scanning-probe-based techniques (e.g., atomic force microscope lithography) [3], and dip-pen lithography [4]. These technologies have proven to be successful in replicating feature sizes around hundreds of nanometers, but they will face great challenges for micrometer scale because of “Proximity Effect”[5]. For example, nanoimprint lithography creates the desired features by displacing polymer materials. This could lead to systematic effects over long distances. A large, dense array with protrusions will displace significantly more polymer than an isolated protrusion. Additionally, there are several other serious drawbacks upon these fabrication methods such as overlay, defects and template wearing.

During the last decades, people have tried molding methods for the fabrication of both active [6] and passive polymer photonic devices within the tri-services including the DARPA MORPH program [7-10]. Of these methods, soft molds using PDMS and hard molds based on silicon has been used to create polymer devices with typical feature size of several micro-meters. Yet the concerns of mold durability, and the capability of transferring patterns into both rigid and flexible substrates are still not completely released. Thus it is highly desirable to develop a low cost, flexible, lithography free fabrication technology for high throughput reproduction of polymer photonic devices that can further advance the manufacturing of polymer integrated photonics with feature size from hundreds of nanometers to several micrometers.

PHASE I: Design a lithography free fabrication method with at least one device implementation with a demonstration of a polymer photonic device. Demonstrate the manufacturability potential of the method so it is obvious that it can be readily commercialized. Determine if the fabrication method would produce polymer photonic devices with lower fabrication cost, and higher throughput as well.

PHASE II: Demonstrate a photolithography-free fabrication method. Resolve technology issues such as yield, defect density, wafer size, and throughput rate. Develop and test 3-D patterning. Demonstrate the capability of transferring patterns to both flexible and rigid substrate with replication rates greater than 104 with the fabrication tools. This phase should conclude with a TRL of 4.

PHASE III: There is value in space-constrained platforms of interest, such as satellites fielded by the Air Force and the NRO because polymer photonics are significantly smaller than the currently used lithium niobate material (military application). Demonstrate scalability and repeatability of the innovative fabrication tool for polymer photonic devices. Industrial production of commercial polymer photonic devices with the fabrication tools should be conducted. The target device is a 40 GHz differential phase shift keying modulator which is used in coherent telecommunications (commercial application). The commercial transition plan is the most likely because it combines the high optical power of a photonic polymer system with the advantage of lower cost and higher volume that lithography-less manufacturing can provide. Transition plan includes successful license acquisition by transceiver manufacturer then transfer to telecommunications equipment manufacturer then deployment to telecommunications service providers.

REFERENCES:
[1] X. M. Zhao, Y. Xia, G. M. Whitesides, “Soft lithographic methods for nano-fabrication,” J. Mater. Chem., 1997, 7, 1069

[2] S.Y. Chou, P. R. Krauss, P. J. Renstrom, “Imprint Lithography with 25-Nanometer Resolution,” Science 1996, 272, 85

[3] S. C. Minne, P. Flueckiger, H. T. Soh, C. F. Quate, “Atomic force microscope lithography using amorphous silicon as a resist and advances in parallel operation,” J. Vac. Sci. Technol.B, 1995, 13, 1380.

[4] R. D. Piner, J. Zhu, F. Xu, S. Hong, C. A. Mirkin, “"Dip-Pen" Nanolithography,” Science, 1999, 283,661.

[5] S. Landis, N Chaix, C Gourgon, C Perret and T Leveder, "Stamp design effect on 100 nm feature size for 8 inch NanoImprint lithography," Nanotechnology, 2006, 17, 2701-2709.

[6] G. T. Paloczi, Y. Huang, A. Yariv, J. Luo, and A. K.-Y. Jen, "Replica-molded electro-optic polymer Mach–Zehnder modulator,"Applied Physics Letter, 2004, 85, 1662

[7] L. Wang, X. L. Wang, W. Jiang, J. Choi, H. Bi, and R. T. Chen, "45º polymer-based total internal reflection coupling mirrors for fully embedded intraboard guided wave optical interconnects," Applied Physics Letters, 2005, 87, 141110

[8] A. L. Martin, D. K. Armani, L. Yang, and K. J. Vahala, "Replica-molded high-Q polymer microresonators," Optics Letters, 2004, 29, 533

[9] C. Y. Chao, and L. J. Guo, "Polymer microring resonators fabricated by nanoimprint technique," J. Vac. Sci. Technol. B, 2002, 20, 2862

[10] X.Y. Dou, X. L. Wang, H.Y. Huang, X.H. Lin, and R. T. Chen, "Polymeric waveguides with embedded micro-mirrors formed by Metallic Hard Mold," Optics Express, 2010, 18, 378

KEYWORDS: polymer photonics, lithography-free manufacturing, modulators, telecommunications

SB103-005 TITLE: Wavelength-Stabilized, High-Brightness Diode Laser Pumps for High-Power Fiber Lasers

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: Demonstrate a wavelength-stabilized, narrow output spectrum, multi-kilowatt fiber-coupled diode laser system with brightness that is at least ten times higher than the current state-of-the-art for pumping high-power fiber laser amplifiers.

DESCRIPTION: High average and peak power fiber lasers and amplifiers have numerous industrial, scientific, and defense applications. Industrial applications include metal cutting, welding, and marking. Scientific applications include inducing laser-guide stars for astronomy, gravitational wave detection, laser cooling and trapping, and laser-based particle accelerators. Defense applications include laser-based weapons, laser-induced spark, and lidar. The small size and high optical-to-optical efficiency of fiber lasers and amplifiers also makes them promising components for scalable high-power laser systems employing spectral or coherent beam combination [1], but the output power and energy from individual fiber lasers and amplifiers have yet to reach their full potential.

The main limitations for scaling fiber lasers and amplifiers to higher power and higher energy are 1) nonlinear optical effects within both the active gain fibers and the passive delivery fibers, 2) spatial and spectral brightness of the optical pump source, and 3) physical limitations such as thermal failure at splices or defects [2, 3]. However, the limitations due to nonlinear effects and pump brightness place conflicting constraints on fiber design. For efficient beam combining, fiber lasers and amplifiers must have a narrow spectral bandwidth, but these narrow-band systems are the most susceptible to stimulated Brillouin scattering (SBS), which is a nonlinear process that can scatter significant power backwards into the sensitive front end of the laser system. Several techniques have been used to suppress SBS, but the most common is to utilize short fibers with large cores to reduce the interaction length and lower the Brillouin gain. Conversely, double-clad fibers require significant length to transfer the pump light from the cladding to the doped core. The cladding-core coupling can be increased (to enable shorter gain fibers) by decreasing the cladding diameter, but smaller cladding size necessitates pump lasers with higher spatial brightness.

In addition, for higher efficiency the pump lasers' spectra must be narrowed and stabilized to match the gain fiber's absorption peak; the peak for Yb-doped silica is at 976 nm and has a width of ~7 nm.

Currently, all state-of-the-art fiber lasers and amplifiers are limited by pump brightness [4]. State-of-the-art diode laser pumps are limited to about 100 W from 100 μm/0.22 NA (numerical aperture) delivery fibers and about 300 W from 200 μm/0.22 NA delivery fibers [5]. DARPA seeks innovative approaches to realizing a wavelength-stabilized, narrow output spectrum, multi-kW fiber-coupled diode laser system with brightness that is at least ten times higher than the current state of the art for pumping high-power fiber laser amplifiers. The resulting pump laser module could be transitioned to multiple government-funded high-power laser programs or commercialized as a part of laser systems targeting industrial applications.

PHASE I: Design a compact wavelength-stabilized, high-brightness, fiber-coupled diode laser system. The key performance goals are: 1) > 5 kW CW from a 100 μm / 0.22 NA (or 200 μm / 0.1 NA) delivery fiber, 2) < 3 nm full-width half-maximum output spectrum, 3) $\Delta\lambda/\Delta T < 0.07$ nm/ºC (where $\Delta\lambda/\Delta T$ refers to the change in output wavelength with a change in temperature), 4) specific weight < 1 kg/kW of fiber-coupled pump power. Perform proof-of-concept demonstrations for critical components (e.g. demonstrate the laser diode brightness from a single bar required for scaling to > 5 kW).

PHASE II: Construct and demonstrate a prototype laser system suitable for pumping high-power fiber lasers based on the Phase I design. The key performance goals are: 1) >5 kW CW from a 100 μm/0.22 NA (or 200 μm/0.1 NA) delivery fiber, 2) <3 nm full-width half-maximum output spectrum, 3) $\Delta\lambda/\Delta T < 0.07$ nm/ºC, 4) specific weight < 1 kg/kW of fiber pump power delivered. Perform detailed thermal and optical modeling on multi-kW-class pump laser. Conduct a preliminary reliability assessment. Phase II should include plans to test the prototype system in a high-fidelity laboratory environment or in a simulated operational environment. The final Phase II system should be at Technology Readiness Level 6.

PHASE III: Wavelength-stabilized, high-brightness, high-efficiency diode lasers will have significant impact in both industrial and military applications. Military applications include lidar and directed-energy weapons, and the Phase II technology could be quickly transitioned to multiple government directed-energy programs, including ongoing high-power fiber laser programs funded by DARPA and HEL-JTO. Industrial applications include metal cutting, welding, and marking. A diode laser system meeting the nominal Phase II requirements would enable higher output power from these systems with reduced cost and size.

REFERENCES:

1. T. Y. Fan, "Laser Beam Combining for High-Power, High-Radiance Sources," IEEE J. Sel. Topics Quant. Electron. 11, pp. 567-577 (2005).

2. J.Nilsson et al, "High-power fiber lasers: New developments", Proc. SPIE 4974, pp. 50-59 (2003).

3. Y. Jeong et al, "Power Scaling of Single-Frequency Ytterbium-Doped Fiber Master-Oscillator Power-Amplifier Sources up to 500 W", IEEE J. Sel. Topics Quantum Electron. 13, pp. 546-551 (2007).

4. R. Hülsewede et al, "Optimized high power diode laser, laser arrays, and bars for pump applications", Proc. SPIE 7198, pp. 71980A (2009).

5. S. R. Karlsen et al, "100-W, 105-μm, 0.15 NA fiber coupled laser diode module", Proc. SPIE 7198, pp.71980T (2009).

KEYWORDS: laser diode; brightness; fiber laser; optical fiber amplifier; laser cutting; laser welding; directed energy; laser weapons.

SB103-006 TITLE: <u>Novel Acoustic Materials for Passive Hearing Protection</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Investigate, identify, and demonstrate acoustic materials that can selectively filter the frequency and/or amplitude of damaging combat noise levels encountered by the Soldier in the battlefield.

DESCRIPTION: Hearing loss is the number one disability facing today's soldiers as they return home from the battlefield. Many soldiers do not wear their issued earplugs for fear of loss of situational awareness. Additionally, one set of traditional earplugs cannot protect against various acoustic threats which range from lower intensity tank noise to the higher intensity noise from gunshots and roadside bomb explosions. State of the art technology offers active ear protection solutions which contain digital processors that block out damaging sound waves and still allow users to hear everyday noises. These solutions however, are not adaptable and are prohibitively expensive for wide-spread deployment. The goal of this solicitation is to develop a low cost, passive ear protection device to be worn as an earplug or headset that will allow the Soldier to maintain situational awareness but filter out harmful noise threats.

Newly developed acoustic meta-materials may be leveraged to address this problem. Meta-materials are composite systems whose bulk properties are derived from the geometric structure rather than the chemical constituents of the material. Recently, significant progress has been made in acoustic metamaterial crystal design to create band gaps which can be used for sound attenuation. DARPA seeks to further the research to utilize system nonlinearities to provide passively tunable systems that can be manufactured using scalable materials including polymers and metals. Acoustic meta-material responses will be explored which can (1) selectively attenuate the noise amplitude at various frequencies and/or (2) filter harmful noise levels while allowing everyday conversation. In addition to nonlinear acoustic meta-materials, other passive solutions will be considered.

PHASE I: Investigate the technical approaches for either (1) A frequency selective acoustic filter for hearing protection with > 12 dB attenuation at frequencies > 3 kHz and < 1 dB attenuation at frequencies < 1 kHz or (2) An intensity (amplitude) filter within audible frequencies (< 20 kHz) that responds to two ranges of sounds levels: Higher intensity levels (> 115 dBA) with > 25 dB attenuation and lower intensities (<65 dBA) with < 1 dB attenuation. The predicted performance of the proposed filters should be evaluated and compared with the existing technology. Identify the approach to be taken in Phase II and provide estimated improvement metrics and manufacturing techniques.

PHASE II: Demonstrate the ability to produce a passive ear protection device that can be worn as an earplug or headset, traceable to a scalable low-cost manufacturing process. The demonstrated filter should have a measurable performance advantage over existing techniques. Deliver a passive hearing protective prototype system. Include plans to test the system in a high-fidelity laboratory or simulated operational environment to validate performance metrics are improved over state of the art. At the end of Phase II, the TRL target is 6.

PHASE III: This program would have significant impact for both DoD and commercial entities due to the ability to passively control noise levels. Impact will include soldier hearing protection systems and occupational safety devices for civilian applications ranging from airline and highway technicians to policemen. Applications include not only ear protection devices, but the materials can also be adapted to sound barriers for both industrial and residential areas. Industrial production of commercial acoustic metamaterial devices should be conducted due to the low cost nature of the technical approach.

REFERENCES:
1. Fok, L., M. Ambati, and X. Zhang, Acoustic Metamaterials. MRS Bulletin, 2008. 33(10): p. 931-934.

2. Herbold, E.B.; Kim, J.; Nesterenko, V.F.; Wang, S.; Daraio, C. "Tunable frequency bandgap and pulse propagation in a strongly nonlinear diatomic chain" Acta Mechanica 205(1-4): 85-103 JUN 2009.

3. Associated Press. "Hearing loss is silent epidemic in U.S. troops", March 7, 2008.

KEYWORDS: metamaterials, acoustic filters, noise reduction, nonlinear, SB103-007 TITLE: Waveform Design, Database, and Development for Radio Communications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop innovative tools and software functions that significantly improve the quality and development cycle time for creation of waveform and protocol software for radio communications systems. Tools and techniques will be developed that allow a communications engineer to design, produce, analyze, document, and validate radio waveform and protocol software required to implement radio communications networks. This effort enables standardized, interoperable waveforms and protocols across multiple processor and FPGA families, and across multiple radio vendors.

DESCRIPTION: Existing defense wireless communication networks consist of many radios utilizing many different physical layer waveforms and protocols. The time required to develop and validate the robust operation of wireless communication waveforms and/or protocols greatly exceeds the development time for the radio hardware – often taking 4 to 5 years for the radio software to meet requirements for robustness and functionality due to the complexity of real time software development. This SBIR program addresses dramatic improvement in radio development and cycle time reduction by enabling development tools that tree waveform and protocol specifications at the communication engineer's level downward to directly produce the analysis, specifications, and rigorous performance tests needed to create radio products. Today, the communication engineer defines a waveform, and then hands off the implementation to software engineers who utilize different tools to redefine the waveform in the traditional tools and methods of software engineering. Once the software is developed it is handed off to the test engineers who utilize another tool suite to create regression tests that validate the waveform robustness. This multiple step process can be simplified by creating the ability for these functions to key directly from the communication engineer's specifications.

DARPA seeks to create a novel systems level approach to software development for use in radio products. This program develops, demonstrates and validates tools that address waveform and protocol software development by enabling the communication engineer to define the properties of the waveform, protocol, network, and radio hardware at the communication network level, simulating the expected performance of his defined waveform(s) and protocols. Innovative tools developed on this SBIR translate the waveform specifications directly from a communications waveform specification into hardware design, software design, firmware design, specification documents, regression tests, and performance validation tests. This enables the communication engineer to directly synthesize and validate the software for communication products, rather than requiring a long hand coded software development cycle.

The results of this effort are expected to produce tool families that dramatically simplify the end to end development process of next generation radios, and the software that runs on these radios. It clearly documents the final software, resulting in bit for bit unambiguous specifications, and far more efficient development and validation processes. The resulting improvement in cycle time will enable much more rapid development of new products and new applications for defense and commercial communications products.

PHASE I: Develop the approaches for languages, architectural components, and proof of concept that shows the expected development process that will be used by the communications engineer, treeing down from communication system requirements analysis, and standardized specifications of the communication functions to automated implementation and requirements validation. Define the code production and validation methodologies.

Phase 1 demonstrations should show that the resulting system will be practical, generate efficient code, and integrate with traditional tools such as compilers, standard operating systems (OS), board support packages, and typical field programmable gate arrays (FPGA) development tools of multiple vendors. Tools developed by this SBIR may integrate one or more of the following functions:

• Protocol & network requirements analysis, specification, development, simulation, and performance validation, requirements traceability
• Automated software / firmware design of standard radio waveforms and protocols
• Partitioning of software / firmware amongst multiple processors
• Porting software across multiple processor types and/or FPGA types

• Dynamic range analysis, optimizing fixed point implementations
• Produce accurate, complete & final design documentation of waveforms, protocols, and partitioning of functions to processors
• Regression test and validate performance requirements of waveform and protocol, provide bit exact test databases at various points in the signal chain
• Validate implementation losses match theory
• Validate encoding /decoding bit fields, error correcting codes, interleavers
• Validate real time performance, memory leakage, interrupt service drivers, and deadlock conditions
• Validate messages passed between multiple processor architectures

Phase I deliverables will include a quarterly technical and financial report of the status of the effort and progress toward accomplishment of research requirements. Phase I requires a final report that describes technical accomplishments, as well as technical and program plan for Phase II activities. The Phase II description will include technical metrics and a risk assessment appropriate for the Phase II proposed effort.

PHASE II: Develop a prototype of the essential architectural components sufficient to demonstrate clear visibility that the resulting system can transition into a viable development tool suite. Testing with a military systems integrator is highly desirable and would provide a large incentive for further development after the end of Phase II. This phase has a target Transition Readiness Level (TRL) of 4 while demonstrating the potential of progressing to TRL 6 during Phase III.

It is expected that the waveform software prototypes created by the tool suite may be able to be utilized to demonstrate rapid development of standardized waveforms targeting a communication radio platform. In addition, there are multiple commercial applications that may be able to utilize the results of this effort for products serving both commercial and government applications.

Phase II deliverables will include quarterly technical and financial reports of the status of the effort and progress toward accomplishment of research requirements. Phase II will also require a final report that includes technical accomplishments, metrics of performance as well as a technical and program plan for Phase III activities. The Phase III description will include technical metrics and a risk assessment appropriate for the Phase III proposed effort.

PHASE III: Advance the tool suite to an implementation of requisite functions to achieve the planned objectives and bring the tool to the level of an Alpha test, then a Beta test product demonstration of its capabilities, and finally transition the tool(s) to a maintained software product business. This resulting product portfolio is expected to result in a capability that can have profound effect on radio communications product development and deployment by dramatically reducing product development and deployment cycle times for defense and commercial radio product developers.

In the defense community there are many companies that develop communication radios. In the commercial field, there are fewer producers but the product volume is much higher, approaching $1T/yr for the world market. The ability to accelerate the software product development process for these industries has enormous defense and commercial value.

REFERENCES: :
1) W.H.Tuttlebee, Software Defined Radio: Baseband Technologies for 3G Handsets and Basestations, Wiley 2004

2) B.A. Jones, “Rapid Prototyping of Wireless Communications Systems”, Thesis Rice University, 2002

3) S. A. Tretter, Communication System Design using DSP Algorithms With Laboratory Experiments, Springer 2003

4) N. Kehtarnavaz, Real Time Digital Signal Processing Based on the TMS320C6000, Newnes 2004

5) U. Meyer-Baese, Digital Signal Processing with Field Programmable Gate Arrays, Springer 2007

KEYWORDS: Software Defined Radio, Cognitive Radio, Waveform development tools, Protocol development tools, automated documentation, automated performance validation, CAD tools

SB103-008 TITLE: High Speed Naval Surface Munition

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: To conceive, design, and demonstrate propulsion, maneuvering control, and engagement capabilities that will enhance the tactical mobility of a small semi-autonomous very high speed maritime surface munition that is capable of speeds of 100 knots or greater in sea state 4 or above.

DESCRIPTION: DARPA is seeking a small munition that fits inside an "A Size" sonobuoy footprint (36 inches long and 4.5 inches in diameter) and is capable of operating on the ocean surface at very high speeds (>100 knots) in sea state 4. The munition must also have the capability to operate at higher speeds in calm water.

This munition will have the ability to pursue targets that are initially a maximum of 3 nautical miles from the munition launch point and transit to the target vicinity (using a combination of internal navigation and external reference such as GPS and vectors provided by other systems). The munition must have the ability to acoustically sense the presence of a group of high speed small boat(s) and then acoustically single out and engage an individual boat from the group. The proposed solution to this topic should represent integrated combinations of advance hull forms, high energy propulsion, and hydrodynamic controls that are capable of achieving a combination of very high speed and good seakeeping characteristics above, below, and on the surface of the water. The munition may leave the surface of the water for short periods and/or skip over waves or penetrate through waves during transit to the target.

In addition, the payload carrying capability (transport factor) of the munition should be considered an important design criteria. For the purposes of this topic, a "surface munition" is defined as one where the interface of the vehicle with the sea surface is a major design driver, displaces water at rest, and operates with near continuous contact with the surface of the water. Although provisions for the weight and volume of an explosive warhead must be considered, this topic does not include the development of the warhead.

Although the SSAMI platform is being designed primarily as a munition, the hull form, controls, and "in and out of water" functionality could eventually be migrated into a maritime platform that could support the at-sea rigging of nets, floats, and lines used in commercial fishing operations and the maintenance of at-sea fisheries. A commercial SSAMI platform variant would have a significant advantage over current manned and unmanned commercial fishing off-board support craft in that the SSAMI could work both "inside and outside the net" because of its ability to jump the floating extreme of the net when necessary.

PHASE I: Develop the conceptual vessel design (including (1) the hullform, (2) the propulsion and (3) the hydrodynamic/aerodynamic control system) for a munition that can be operated at high speeds while both entering and exiting the water while enroute to a surface vessel target. Existing sensing, communications, and navigation sub-systems should be used; development of these subsystems is not an objective of this phase of the project. Demonstrate a proof-of-concept model of the proposed solution through stability analysis, hydrodynamic modeling, and system level simulation. The use and/or modification of existing control software should be defined where possible and the requirement for the development of new software in later stages should be identified. Also identify areas of highest risk and how those risks would be managed and mitigated in Phases II and III.

PHASE II: Perform a detailed integrated design of the vessel's hullform, propulsion, and control systems. Demonstrate the final design concept through (1) rigorous modeling and simulation of the software control systems,

(2) physical tests of a scale model bread-board prototype containing representations of the hull, the propulsion system, and the control system, and (3) conduct an open-sea test/demonstration of an integrated scale model bread-board of the prototype munition against a maneuvering unmanned boat. For the open sea test, the speeds and ranges will be less than those required for the Phase III development effort. This phase will end with a TRL 5 prototype demonstration at scaled speed in representative sea-state.

PHASE III: Build three full-scale and full speed prototype munitions based on the lessons learned from Phase II bread-board prototype testing. The prototypes will have a full speed (100 knot +) capability in sea state 4 and the capability to transit the full 3 nautical mile tactical range and pursue highly maneuvering small boats. The further development and improvement of required sensing, communications, and navigation sub-systems will be undertaken during this phase of the project. After satisfactory integrated hull testing and the integration of any required improvements in the sensing, communications, and navigation sub-systems, build a significant number of SSAMI munitions for pre-production testing and TRL-7 tactical experimentation against realistic numbers of representative enemy swarm boats.

REFERENCES:
1) U.S. NAVY Tactics, Techniques, and Procedures (NTTP) publication 3-02.1.4M (U.S. MARINE CORPS MCWP 3-31.8), entitled: DEFENSE OF THE EXPEDITIONARY STRIKE GROUP, EDITION SEPTEMBER 2006. An html version of the file is available at: https://www.iimef.usmc.mil/iimef/mebops.nsf/All /6DC68EDC96CB129085257515004A9643/$file/3-02-1-4M_(Sep_2006)_(NTTP).pdf.

2) U.S. NAVY Naval Weapons Publication (NWP) 3-62M (U.S. MARINE CORPS MCWP 3-31.7), entitled: SEABASING, EDITION AUGUST 2006, published jointly by the NAVY WARFARE DEVELOPMENT COMMAND and the MARINE CORPS COMBAT DEVELOPMENT COMMAND.

KEYWORDS: High-speed Naval munition, seakeeping, advanced hullform, propulsion, propulsors, hydrodynamic control