Small Business Innovation Research (SBIR) and
Small Business Technology Transfer (STTR)
Opportunity Announcement
HR001120S0019-06
Open Source Wide Band Software Defined Acoustic Modem

Which program will fund this topic?
SBIR
What type of proposals will be accepted?
Both Phase I and Direct to Phase II (DP2)

Technology Area(s): Battle Space, Ground/Sea Vehicles
DARPA Program: 1) Expeditionary Maritime Mine Countermeasures UUV; 2) Manta Ray

I. I INTRODUCTION

The Defense Advanced Research Projects Agency (DARPA) Small Business Programs Office (SBPO) is issuing an SBIR/STTR Opportunity (SBO) inviting submissions of innovative research concepts in the technical domain(s) of Battle Space, Ground/Sea Vehicles. In particular, DARPA is interested in understanding the feasibility of an Open Source Wide Band Software Defined Acoustic Modem.

This SBO is issued under the Broad Agency Announcement (BAA) for SBIR/STTR, HR001120S0019. All proposals in response to the technical area(s) described herein will be submitted in accordance with the instructions provided under HR001120S0019, found here: https://beta.sam.gov/opp/b8abeb02f16a4450b2c2f859fc00c177/view.

a. Eligibility

The eligibility requirements for the SBIR/STTR programs are unique and do not correspond to those of other small business programs. Please refer to Section 3.1, Eligible Applicants, of HR001120S0019 for full eligibility requirements.

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. Proposers 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 applicable proposal preparation instructions. Please refer to Section 2.3 of the Announcement for further information on Export Control.

b. Anticipated Structure/Award Information

Please refer to Section 1, Funding Opportunity Description provided in HR001120S0019 for detailed information regarding SBIR/STTR phase structure and flexibility.

If a proposer can provide adequate documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of the topic has been met

and describes the potential commercial applications, the Direct to Phase II (DP2) authority allows the Department of Defense (DoD) to make an award to a small business concern under Phase II of the SBIR program without regard to whether the small business concern was provided an award under Phase I of an SBIR program. This SBO is accepting DP2 proposal submissions.

For this SBO, DARPA will accept Phase I proposals for cost of up to $225,000 for a 6-month period of performance. The phase structure of this SBIR includes both a Phase I feasibility study and a Phase II major research and development effort. The Phase I feasibility study should demonstrate or determine the scientific, technical, and commercial merit and feasibility of the proposed concept. The Phase II effort should culminate in a well-defined deliverable prototype meeting the objectives of this SBIR topic.

The duration of Phase I performance should not exceed 6 months. The duration of Phase II performance should not exceed 12 months. An accelerated performance schedule is allowed and encouraged if substantiated in the proposal.

Funding is anticipated to not exceed $225,000 for each Phase I award and $1,000,000 for each Phase II or DP2 award. Multiple awards are anticipated for this SBIR topic.

DARPA will accept DP2 proposals for cost of up to $1,250,000. This includes a 12-month base period not to exceed a cost of $1,000,000; at this time it is not anticipated that there will be a D2P option period. A separately priced option of up to $250,000 must also be proposed for contractors who would like to be considered for participation in the DARPA Entrepreneurial Investigator Initiative. Refer to Section 2.6, DARPA Embedded Entrepreneur Initiative, of DARPA HR001120S0019 for detailed information on EEI.

Proposers should refer to Section 4, Application and Submission Information, of HR001120S0019 for detailed proposal preparation instructions. Proposals that do not comply with the requirements detailed in HR001120S0019 and the research objectives of this SBO are considered non-conforming and therefore are not evaluated nor considered for award.

Phase I proposals shall not exceed 20 pages. Phase I commercialization strategy shall not exceed 5 pages. This should be the last section of the Technical Volume and will not count against the 20-page limit. Please refer to Appendix A of HR001120S0019 for detailed instructions on Phase I proposal preparation.

DP2 Feasibility Documentation shall not exceed 40 pages. DP2 Technical Proposal shall not exceed 40 pages. Phase II commercialization strategy shall not exceed 5 pages. It should be the last section of the Technical Volume and will not count against the 40-page limit. Please refer to Appendix B of HR001120S0019 for detailed instructions on DP2 proposal preparation.

c. Evaluation of Proposals

Section 5, Evaluation of Proposals, in HR001120S0019 provides detailed information on proposal evaluation and the selection process for this SBO.

d. Due Date/Time

Full proposal packages (Proposal Cover Sheet, Technical Volume, Price/Cost Volume inclusive of supporting documentation, and Company Commercialization Report) must be submitted via the DoD SBIR/STTR Proposal Submission website per the instructions outlined in HR001120S0019 no later than **2:00 pm ET, May 26, 2020.**

II. TOPIC OVERVIEW

a. Objective

Develop a highly modular and wide band software defined acoustic communication system for incorporation into predefined unmanned underwater vehicle (UUV) payload volumes to provide a reliable alternative to legacy acoustic modems.

b. Description

Communication in the undersea environment spans a vast range of needs including high bandwidths at short distances to low bandwidth at long distances and everything in between. Missions may include long distance communication between nodes or passing of large data such as images or streaming video between undersea units. Commercialization trends for the oil and gas industry as well as undersea scientific exploration continue to grow; however, needs for improved undersea communications from the currently limited options of acoustic communications systems persist.

The current state of practice for UUV communications involves highly constrained, static communication protocol and keying methods based on closed commercial standards. Performers will be tasked to conduct research and development for innovative wide band, highly dynamic acoustic communications systems capable of enabling low cost, open-source architecture fielding in UUVs or similar undersea nodes. Employment of the resulting system would enable advances in affordable underwater command and control by ensuring that dynamic undersea communication is not impeded by environmental noise, fixed frequency ranges of operation, or non-open standards.

This SBIR will design, develop, test, and field an acoustic software defined communications system with open-source architecture software. Solutions will include definitions for communication methods and protocols as well as the widest possible bandwidth (e.g. 1 Hz to 10 MHz) for demonstration to enable underwater command and control. Both narrow and spread spectrum acoustic communications will be supported such that the result is capable of integration by the end user into an expendable UUV or similar low cost undersea node. Spread spectrum solutions that minimize disturbances to or noise from environmental acoustic sources while communicating are encouraged but not required.

Delivery of a highly programmable acoustic communications capability should allow for lower power output, significant reduction in cost, and development of capabilities beyond the current state of practice. The intention of this SBIR is to demonstrate the widest possible acoustic communications capacity and optimization at a sufficiently low price point to allow one or more expendable UUVs to coordinate during a nominal multi-UUV exercise in an open architecture environment for communication protocol development.

The experimentation conducted as part of this SBIR should yield integrated measurements of performance throughout both littoral and deep sea ocean environments. Solutions should be robust to environmental effects such as multi-path propagation.

A desired performance output objective is a flat 185 dB re 1 μPa; however, acceptable output should achieve the following minimum outputs: 100 dB re 1 μPa for 1-100Hz, 120 dB re 1 μPa for 100-1,000Hz, 140 dB re 1 μPa for 1,000-10,000Hz, 165 dB re 1 μPa for 10,000-100,000Hz, and 185 dB re 1 μPa for 100,000-10,000,000Hz.

Size, weight, and power design guidelines for this SBIR topic include the following:

- Notional volume constraints for electronic components should be cylindrical and capable of fitting into a 3 inch diameter by 6 inch length space. While volume constraints for the acoustic transducers are not specified, innovations for miniaturization of transducers are within scope of this SBIR.
- Weight for the electronic components should nominally be limited to 0.25 lb not to exceed 5 lbs when including transducers and other possible transmitter/receiver elements.
- Power should not exceed currently fielded UUV communications systems.

Novel component solutions not addressing all requirements of this SBIR topic may be considered on a case basis. An example would include revolutionary miniaturization of acoustic transducers for use in the described system. Incremental changes from the current state of practice are not desired.

Systems will be prototyped at the bench level early in Phase II by the performer. The systems should be integrated to Government-provided UUV assets for in-water experimentation later in Phase II. Details regarding timing of milestones may be found in the Phase I and Phase II descriptions below.

c. Phase I

Performers will be expected to document and substantiate their proposed solution including prototype architectures and algorithms, quantification of accuracy, quantification of robustness to errors, and major deviations from legacy acoustic modems and communication definitions (such as inductor and capacitor banks as opposed to microelectronics packages). Critical design metrics associated with acoustic bandwidth, power, and open-source architecture for ease of communication protocol implementation should be documented and substantiate the proposer's ability to proceed to Phase II.

Schedule/Milestones/Deliverables
Phase I fixed payable milestones for this program should include:

- Month 1: Report on initial architectures, algorithms, and design approaches
- Month 3: Report on design progress including architectures, algorithms, proposed evaluation metrics, and results of initial analyses
- Month 6: Final Phase I Report summarizing approach; prototype architectures and algorithms; quantification of accuracy; quantification of robustness to errors; and major deviations from legacy acoustic modems and communication definitions; critical design metrics for Phase II including acoustic bandwidth, power, and open-source architecture

d. Phase II

Performers will be expected to develop payload systems at the bench level and subsequently test in a representative in-water environment onboard a Government-provided UUV in conformance with the size, weight, and power constraints provided in Section II.b of this SBIR topic.

A desired performance output objective is a flat 185 dB re 1 μPa; however, acceptable output should achieve the following minimum outputs: 100 dB re 1 μPa for 1-100Hz, 120 dB re 1 μPa for 100-1,000Hz, 140 dB re 1 μPa for 1,000-10,000Hz, 165 dB re 1 μPa for 10,000-100,000Hz, and 185 dB re 1 μPa for 100,000-10,000,000Hz. It is important to note that design of the modem system does not necessarily include design of transducer technologies which may be required to facilitate wide band and sufficient power for said modems to operate.

Performers will be expected to produce a final bench test prototype design and initial simulation within 3 months of beginning execution of Phase II. The subsequent integration and testing at sea or in pools will be conducted with said prototype by a Government testing agent no later than Month 11 as described in the Schedule/Milestones/Deliverables description.

Schedule/Milestones/Deliverables
Phase II fixed milestones for this program should include the following and not exceed the specified months. An accelerated milestone and deliverable schedule is allowed and encouraged if substantiated in the proposal. All Phase II months are relative to Phase II kick off for a total notional Phase II duration of 12 months.

- Month 1: Report on fielding plan and proposed evaluation metrics
- Month 3: Interim report describing final bench test design, initial simulation results of prototype system, and preliminary in-water test plan, sequence, and schedule
- Month 5: Report describing final bench test results and updated simulation results of prototype system
- Month 6: Report on final in-water prototype design
- Month 7: Report of in-water testing plan, sequence, and schedule

- Month 11: Complete in-water testing in representative environment in conjunction with Government testing agent
- Month 12: Final Phase II in-water demonstration report documenting final prototype design; final prototype testing; methods; simulation, benchtop, and in-water results; comparisons with alternative methods; open-source architecture interfaces; and quantification of accuracy, robustness, and generalizability

e. Dual Use Applications (Phase III)

Dual use applications may be found in the miniaturization of electronic-based communications devices for both defense and commercial UUV applications including but not limited to the oil and gas industry as well as undersea scientific exploration. The ability to reapply the miniaturized components of one communications payload to an infinite number of other undersea robotics problems is created under this scope. Demonstrating discrete and miniaturized communications payloads on expendable UUV platforms opens a new design space for a traditionally monolithic undersea mission sets. Businesses will then be able to design, develop, test, and field other similar capabilities using expendable UUVs outfitted with miniaturized payloads.

f. References

[1] S. Sendra, J. Lloret, J. M. Jimenez and L. Parra, "Underwater Acoustic Modems," in IEEE Sensors Journal, vol. 16, no. 11, pp. 4063-4071, June 1, 2016. doi: 10.1109/JSEN.2015.2434890

[2] Catipovic, J., & Etchemendy, S. (1993). Development of Underwater Acoustic Modems and Networks. Oceanography, 6(3), 112-119. www.jstor.org/stable/43924652

[3] Jurdak, R., Lopes, C. V., & Baldi, P. (2007, May). Software acoustic modems for short range mote-based underwater sensor networks. In OCEANS 2006-Asia Pacific (pp. 1-7). IEEE.

[4] Dol, H. S., Casari, P., Van Der Zwan, T., & Otnes, R. (2016). Software-defined underwater acoustic modems: Historical review and the NILUS approach. IEEE Journal of Oceanic Engineering, 42(3), 722-737.

[5] Nowsheen, N., Benson, C., & Frater, M. (2010, September). A high data-rate, software-defined underwater acoustic modem. In OCEANS 2010 MTS/IEEE SEATTLE (pp. 1-5). IEEE.

[6] Demirors, E., Sklivanitis, G., Melodia, T., Batalama, S. N., & Pados, D. A. (2015). Software-defined underwater acoustic networks: toward a high-rate real-time reconfigurable modem. IEEE Communications Magazine, 53(11), 64-71.

g. Keywords

UUV communications, acoustic modem, software defined, acoustic communications

III. SUBMISSION OF QUESTIONS

DARPA intends to use electronic mail for all correspondence regarding this SBO. Questions related to the technical aspect of the research objectives and awards specifically related to this SBO should be emailed to HR001120S0019@darpa.mil. Please reference BAA HR001120S0019-06 in the subject line. All questions must be in English and must include the name, email address, and the telephone number of a point of contact.

DARPA will attempt to answer questions in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered. DARPA will post a consolidated Frequently Asked Questions (FAQ) document. To access the posting please visit: http://www.darpa.mil/work-with-us/opportunities. Under the HR001120S0019-06 summary, there will be a link to the FAQ. The FAQ will be updated on an ongoing basis until one week prior to the proposal due date.

In addition to the FAQ specific to this SBO, proposers should also review the SBIR/STTR General FAQ list at: http://www.darpa.mil/work-with-us/opportunities?tFilter=&oFilter=29934. Under the HR001120S0019 summary, there is a link to the general FAQ.

Technical support for the Defense SBIR/STTR Innovation Portal (DSIP) is available Monday through Friday, 9:00 a.m. – 5:00 p.m. ET. Requests for technical support must be emailed to DoDSBIRSupport@reisystems.com with a copy to HR001120S0019@darpa.mil.