DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)
15.2 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

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IMPORTANT NOTE REGARDING THESE INSTRUCTIONS

THESE INSTRUCTIONS ONLY APPLY TO PROPOSALS SUBMITTED IN RESPONSE TO DARPA 15.2 PHASE I TOPICS.

Offerors responding to DARPA topics listed in Section 12.0 of this Solicitation must follow all the instructions provided in the DoD Program Solicitation AND the supplementary DARPA instructions contained in this section. The section/paragraph numbering in these instructions is intended to correspond with the section/paragraph numbering of the 15.2 DoD Program Solicitation (http://www.acq.osd.mil/osbp/sbir/index.shtml).

1.0 INTRODUCTION

DARPA's mission is to prevent technological surprise for the United States and to create technological surprise for its adversaries. The DARPA SBIR Program is 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
675 North Randolph Street
Arlington, VA 22203-2114
sbir@darpa.mil
Home Page http://www.darpa.mil/Opportunities/SBIR_STTR/SBIR_STTR.aspx

System Requirements

Use of the DARPA SBIR/STTR Information Portal (SSIP) is MANDATORY. Offerors will be required to authenticate into the SSIP (via the DARPA Extranet) to retrieve their source selection decision notice, to request debriefings, and to upload reports (awarded contracts only). DARPA SBPO will automatically create an extranet account for new users and send the SSIP URL, authentication credentials, and login instructions AFTER the 15.2 source selection period has closed. DARPA extranet accounts will ONLY be created for the individual named as the Corporate Official (CO) on the proposal coversheet. Offerors may not request accounts for additional users at this time.

WARNING: The Corporate Official (CO) e-mail address (from the proposal coversheet) will be used to create a DARPA Extranet account. Updates to Corporate Official e-mail after proposal submission may cause significant delays to communication retrieval and contract negotiation (if selected). Additional information in section 4.0.

3.0 DEFINITIONS

3.4 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/EAR requirements.

3.5 Foreign National

Foreign Nationals (also known as Foreign Persons) means any person who is NOT:

a. a citizen or national of the United States; or
b. a lawful permanent resident; or
c. a protected individual as defined by 8 U.S.C. § 1324b

ALL offerors proposing to use foreign nationals MUST follow section 5.4. c.(8) of the DoD Program Solicitation and disclose this information regardless of whether the topic is subject to ITAR restrictions. There are two ways to obtain U.S. citizenship: by birth or by naturalization. Additional information regarding U.S. citizenship is available at http://travel.state.gov/law/citizenship/citizenship_782.html. Definitions for "lawful permanent resident" and "protected individual" are available under section 3.5 of the DoD Program Solicitation.

4.0 PROPOSAL FUNDAMENTALS

4.6 Classified Proposals

DARPA topics are unclassified; however, the subject matter may be considered to be a "critical technology" and therefore subject to ITAR/EAR restrictions. See **Export Control** requirements above in Section 3.1.

4.7/4.8 Human or Animal Subject Research

DARPA discourages offerors from proposing to conduct Human or Animal Subject Research during Phase I due to the significant lead time required to prepare the documentation and obtain approval, which will delay the Phase I award. See sections 4.7 and 4.8 of the DoD Program Solicitation for additional information.

4.10 Debriefing

DARPA will provide a debriefing to the offeror in accordance with Federal Acquisition Regulation (FAR) 15.505. The source selection decision notice (reference 4.4 Information on Proposal Status) contains instructions for requesting a proposal debriefing. Please also refer to section 4.10 of the DoD Program Solicitation.

Notification of Proposal Receipt

Within 5 business days after the solicitation closing date, the individual named as the "Corporate Official" on the Proposal Cover Sheet will receive a separate e-mail from sbir@darpa.mil acknowledging receipt for each proposal received. Please make note of the topic number and proposal number for your records.

Notification of Proposal Status

The source selection decision notice will be available no later than **90 days after solicitation close.** The individual named as the "Corporate Official" on the Proposal Cover Sheet will receive an email for each proposal submitted, from sbir@darpa.mil with instructions for retrieving their official notification from the SSIP. Please read each notification carefully and note the proposal number and topic number referenced. The CO must retrieve the letter from the SSIP 30 days from the date the e-mail is sent. After 30 days the CO must make a written request to sbir@darpa.mil for source selection decision notice. The request must explain why the offeror was unable to retrieve the source selection decision notice from the SSIP within the original 30 day notification period. Please also refer to section 4.0 of the DoD Program Solicitation.

4.11 Solicitation Protests

Interested parties may have the right to protest this solicitation by filing directly with the agency by serving the Contracting Officer (listed below) with the protest, or by filing with the Government Accountability Office (GAO). If the protest is filed with the GAO, a copy of the protest shall be received in the office designated below within one day of filing with the GAO. The protesting firm shall obtain written and dated acknowledgment of receipt of the protest.

Agency protests regarding the solicitation should be submitted to:
SBIR/STTR Solicitation Contracting Officer
WHS/Acquisition Directorate
1155 Defense Pentagon
Washington, DC 20301-1155
E-mail: jonathan.l.becker2.civ@mail.mil

Agency protests regarding the source selection decision should be submitted to:
DARPA
Contracts Management Office (CMO)
675 N. Randolph Street
Arlington, VA 22203
E-mail: scott.ulrey@darpa.mil and sbir@darpa.mil

4.13 Phase I Award Information

a. Number of Phase I Awards. 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 multiple proposals in a topic area, or it may not fund any proposals in a topic area.

b. Type of Funding Agreement. DARPA Phase I awards will be Firm Fixed Price contracts.
c. Dollar Value. The maximum dollar value for a DARPA Phase I award shall not exceed $155,000.
d. Timing. The DoD goal for Phase I award is within 120 calendar days from the proposal receipt deadline. Phase I contract award may be delayed if the offeror fails to include sufficient documentation to support its cost proposal.

4.22 Discretionary Technical Assistance (DTA)

Offerors that are interested in proposing use of a vendor for technical assistance must complete the following:

1. Indicate in question 17, of the proposal coversheets, that you request DTA and input proposed cost of DTA (in space provided).
2. Provide a one-page description of the vendor you will use and the technical assistance you will receive. The description should be included as the LAST page of the Technical Volume. This description will not count against the 20-page limit of the technical volume and will NOT be evaluated.
3. Enter the total proposed DTA cost, which shall not exceed $5,000, under the "Discretionary Technical Assistance" line along with a detailed cost breakdown under "Explanatory material relating to the cost proposal" via the online cost proposal.

DTA requests must be explained in detail with the cost estimate. The cost cannot be subject to any profit or fee by the requesting firm. In addition, the DTA provider may not be the requesting firm itself, an affiliate or investor of the requesting firm, or a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g., research partner).

Approval of technical assistance is not guaranteed and is subject to review of the Contracting Officer. Please see section 4.22 of the DoD Program Solicitation for additional information.

5.0 PHASE I PROPOSAL

Phase I Option

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 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 statement of work for the Phase I Option counts toward the 20-page limit for the Technical Volume.

5.4.c.(6) Commercialization Strategy

DARPA is equally interested in dual use commercialization of SBIR project results to the U.S. military, the private sector market, or both, and expects explicit discussion of key activities to achieve this result in the commercialization strategy part of the proposal. The discussion should include identification of the problem, need, or requirement relevant to a DoD application and/or a private sector application that the SBIR project results would address; a description of how wide-spread and significant the problem, need, or requirement is; and identification of the potential DoD end-users, Federal customers, and/or private sector customers who would likely use the technology.

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 and commercialization activities. The small business must convey an understanding of the preliminary transition path or paths to be established during the Phase I project. That plan should include the Technology Readiness Level (TRL) expected at the end of the Phase I. The plan should include anticipated business model and potential private sector and federal partners the company has identified to support transition and commercialization activities. In addition, key proposed milestones anticipated during Phase II such as: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.

5.5 Phase I Proposal Checklist

Complete proposals must contain the following elements. Incomplete proposals will be rejected.

____1. Volume 1: Completed Coversheet.
____ a. Completed and checked for accuracy.
____ b. Costs for the base and option (if proposed) are clearly separate and identified on the Proposal Cover Sheet.

____2. Volume 2: Technical Volume.
____ a. Numbered all pages of the proposal consecutively. The cover sheets are pages 1 and 2. The technical volume begins on page 3.
____ b. Font type is no smaller than 10-point on standard 8½" x 11" paper with one-inch margins. The header on each page of the technical proposal contains the company name, topic number and proposal number assigned by the DoD SBIR/STTR Electronic Submission Web site when the cover sheet was created. The header may be included in the one-inch margin.
____c. Include documentation required for Discretionary Technical Assistance (if proposed).
____d. The technical volume does not exceed twenty (20) pages. Any page beyond 20 will be redacted prior to evaluations.

____3. Volume 3: Cost Volume.
____a. Used the online cost proposal.
____b. Subcontractor, material and travel costs in detail. Used the "Explanatory Material Field" in the DoD Cost Volume worksheet for this information, if necessary.
____c. Costs for the base and option (if proposed) are clearly separate and identified in the Cost Volume.
____d. Base effort does not exceed $100,000 or $105,000 if DTA services are proposed.
____e. Option (if proposed) does not exceed $50,000.
____f. If proposing DTA, cost submitted in accordance with instructions in section 4.22 and does not exceed $5,000.

____4. Volume 4: Company Commercialization Report
____a. Completed and checked for accuracy. Follow requirements specified in section 5.4(e).

____5. Submission
____a. Upload four completed volumes: Volume 1: Proposal Cover Sheet; Volume 2: Technical Volume; Volume 3: Cost Volume; and Volume 4: Company Commercialization Report electronically through the DoD submission site by 6:00 AM (ET) on June 24, 2015.
____b. Review your submission after upload to ensure that all pages have transferred correctly and do not contain unreadable characters. Contact the DoD Help Desk immediately with any problems (see section 4.15).
____c. Submit your proposal before 6:00 AM (ET) on June 24, 2015. DARPA will NOT accept proposals that have NOT been submitted by the solicitation deadline.

6.0 PHASE I EVALUATION CRITERIA

Phase I proposals will be evaluated in accordance with the criteria in section 6.0 of the DoD Program Solicitation.

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 Agreements and Rules of Conduct/Conflict of Interest statements. Non-Government technical consultants/experts will not have access to proposals that are labeled by their offerors as "Government Only".

Advocacy Letters

Please note that qualified advocacy letters will count towards the proposal page limit and will be evaluated towards criterion C. Advocacy letters are not required. Consistent with Section 3-209 of DoD 5500.7-R, Joint Ethics Regulation, which as a general rule prohibits endorsement and preferential treatment of a non-federal entity, product, service or enterprise by DoD or DoD employees in their official capacities, letters from government personnel will NOT be accepted.

A qualified advocacy letter is from a relevant commercial procuring organization(s) working with a DoD or other Federal entity, articulating their pull for the technology (i.e., what need the technology supports and why it is important to fund it), and possible commitment to provide additional funding and/or insert the technology in their acquisition/sustainment program. If submitted, the letter should be included as the last page of your technical proposal. Advocacy letters which are faxed or e-mailed separately will NOT be accepted.

Limitations on Funding

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 multiple proposals in a topic area, or it may not fund any proposals in a topic area. Phase I awards and options are subject to the availability of funds.

7.0 PHASE II PROPOSAL

All offerors awarded a Phase I contract under this solicitation will receive a notification letter with instructions for preparing and submitting a Phase II Proposal and a deadline for submission. Visit http://www.darpa.mil/Opportunities/SBIR_STTR/SBIR_Program.aspx for more information regarding the Phase II proposal process.

11.0 CONTRACTUAL CONSIDERATIONS

11.1(r) Publication Approval (Public Release)

National Security Decision Directive (NSDD) 189 established the national policy for controlling the flow of scientific, technical, and engineering information produced in federally funded fundamental research at

colleges, universities, and laboratories. The directive defines fundamental research as follows: "Fundamental research" means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.

It is DARPA's goal to eliminate pre-publication review and other restrictions on fundamental research except in those exceptional cases when it is in the best interest of national security. Please visit http://www.darpa.mil/NewsEvents/Public_Release_Center/Public_Release_Center.aspx for additional information and applicable publication approval procedures.

11.4 Patents

Include documentation proving your ownership of or possession of appropriate licensing rights to all patented inventions (or inventions for which a patent application has been filed) that will be utilized under your proposal. If a patent application has been filed for an invention that your proposal utilizes, but the application has not yet been made publicly available and contains proprietary information, you may provide only the patent number, inventor name(s), assignee names (if any), filing date, filing date of any related provisional application, and a summary of the patent title, together with either: (1) a representation that you own the invention, or (2) proof of possession of appropriate licensing rights in the invention. Please see section 11.4 of the DoD Program Solicitation for additional information.

11.5 Intellectual Property Representations

Provide a good faith representation that you either own or possess appropriate licensing rights to all other intellectual property that will be utilized under your proposal. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights that describes the nature of the restriction and the intended use of the intellectual property in the conduct of the proposed research. Please see section 11.5 of the DoD Program Solicitation for information regarding technical data rights.

11.7 Phase I Reports

All DARPA Phase I awardees are required to submit reports in accordance with the Contract Data Requirements List – CDRL and any applicable Contract Line Item Number (CLIN) of the Phase I contract. Reports must be provided to the individuals identified in Exhibit A of the contract. Please also reference section 4.0 of the DoD Program Solicitation.

Direct to Phase II

15 U.S.C. §638(cc), as amended by NDAA FY2012, Sec. 5106, PILOT TO ALLOW PHASE FLEXIBILITY, allows the DoD to make an award to a small business concern under Phase II of the SBIR program with respect to a project, without regard to whether the small business concern was provided an award under Phase I of an SBIR Program with respect to such project.

DARPA is conducting a "Direct to Phase II" pilot implementation of this authority for this 15.2 SBIR solicitation only and does not guarantee the pilot will be offered in future solicitations.

Not all DARPA topics are eligible for a Direct to Phase II award. Potential offerors should read the topic requirements carefully. Topics may accept Phase I and Direct to Phase II proposals, Phase I proposals only, or Direct to Phase II proposals only – refer to the 15.2 Topic Index to review proposal types accepted against each topic. DARPA reserves the right to not make any awards under the Direct to Phase II pilot. All other instructions remain in effect. Direct to Phase II proposals must follow the instructions in the DARPA Direct to Phase II Solicitation Instructions.

DARPA SBIR 15.2 Topic Index

*These instructions **ONLY** apply to Phase I Proposals. **For Direct to Phase II, refer to the DARPA 15.2 Direct to Phase II (DP2) Topics and Proposal Instructions** available at (http://www.acq.osd.mil/osbp/sbir/index.shtml).*

		Proposals Types Accepted	
Topic Number	**Topic Title**	**Phase I**	**DP2**
SB152-001	Cell Free Platforms for Prototyping and Biomanufacturing	YES	NO
SB152-002	Cortical Modem Systems Integration and Packaging	YES	YES
SB152-003	Broadband Self-calibrated Rydberg-based RF Electric Field and Power Sensor	YES	YES
SB152-004	Many-Core Acceleration of Common Graph Programming Frameworks	YES	YES
SB152-005	Ovenized Inertial Micro Electro Mechanical Systems	YES	NO
SB152-006	Compact, Configurable, Real-Time Infrared Hyperspectral Imaging System	YES	YES
SB152-007	Depth Insensitive Pressure/Vector Sensor Arrays	NO	YES
SB152-008	Low Cost Expendable Launch Technology	YES	NO

SB152-001 TITLE: Cell Free Platforms for Prototyping and Biomanufacturing

PROPOSALS ACCEPTED: Phase I Only

TECHNOLOGY AREAS: Materials/Processes, Biomedical

OBJECTIVE: Improve the ability to rationally and predictably engineer biology by developing cell-free methods for rapid, low-cost, and high-throughput prototyping of biological functions and systems capable of providing an accurate characterization of in vivo performance.

DESCRIPTION: There is a critical need for capabilities that will enable DoD to leverage the unique and powerful attributes of biology to solve challenges associated with production of new materials, novel capabilities, fuels, and medicines. This topic is focused on improving the utility of cell-free systems as a platform technology to address key technical hurdles associated with current practices in engineering biology.

A successful platform should address several or all of the bottlenecks associated with the state-of-the-art in cell-free systems, including production of cell-free reagents with improved consistency and scalability, improved methods for characterizing and validating cell-free reagent preparations, new cell-free systems to expand the number of organisms capable of being modeled, and improved reproducibility of results over scaled volumes. In addition, these cell-free platforms should be distributable in a format that can be readily transitioned to academic, government, and commercial researchers, all of whom rely on the ability to rapidly assay engineered biological systems.

Biological production platforms have great potential to provide new materials, capabilities, and manufacturing paradigms for the Department of Defense (DoD) and the Nation. However, the complete realization of this potential has been limited by current approaches to engineering biology that rely on ad hoc, laborious, and time-consuming processes, as well as the large amount of trial and error required to generate designs of even moderate complexity.

One technology that could address many of these bottlenecks is the use of cell-free systems for the rapid prototyping and testing of biological systems. Conventional approaches to engineering genetic systems rely on molecular cloning into DNA vectors, transformation or transfection of cells, antibiotic resistance-based selection, growth in appropriate media, and assaying cells for the desired function. While significant progress has been made toward improving these processes, engineering living cells is inherently costly, slow, and complex.

By short circuiting many of the steps required for in vivo gene expression, cell-free systems offer several advantages that could potentially transform the state-of-the-art, including reduced cost, increased throughput, decreased system complexity, and the ability to be utilized in a distributed setting. In addition, cell-free systems enable the production and testing of cytotoxic compounds, the prototyping of pathways with toxic metabolic intermediates, and for the production of molecules, such as proteins containing non-standard amino acids, that are difficult to engineer into living systems. Although the use of cell-free assays has significant potential to rapidly engineer and test biological systems, several technical hurdles remain that have prevented widespread adoption of the technology.

Methods for preparing reagents used in cell-free experiments are often inconsistent, which can lead to irreproducible results. In addition, current methods do not produce batches of a sufficient volume of high

quality reagent to enable widespread use. Furthermore, existing internal controls are insufficient for the complete characterization and validation of reagents, which makes instituting process controls difficult. The cell-free platform itself also requires improvement, as only relatively simple biological processes have been demonstrated and in only a handful of organismal environments.

PHASE I: Develop an initial design and determine the technical feasibility of a technology platform for the consistent and large-scale production of cell-free reagents from multiple organisms, including methodologies for characterization and validation. Develop detailed analysis of the cell-free platform's predicted performance characteristics including, but not limited to, total volume of reagent to be produced, batch volume and variability, organisms to be utilized, cost per unit, and distribution format. Include analysis of predicted performance relative to current standard practices. Define key component technological milestones and metrics and establish the minimum performance goals necessary to achieve successful execution of the cell-free platform. Phase I deliverables will include: a detailed analysis of the proposed platform, a technical report detailing experiments and results supporting the feasibility of the approach, and defined milestones and metrics as appropriate for the program goals. Also included with the Phase I deliverables is a Phase II plan for transitioning initial designs and proof-of-concept experiments into protocols that are sufficiently robust and reproducible to be viable as commercial technologies.

PHASE II: Finalize the design from Phase I and initiate the development and production of the cell-free platform. Establish appropriate performance parameters through experimentation to determine the efficaciousness, robustness, and fidelity of the approach being pursued. Develop, demonstrate, and validate the reagents and protocols necessary to meet the key metrics as defined for the program, and provide an experimentally validated comparison of the new methods relative to competing state-of-the-art processes. Phase II deliverables include a prototype set of cell-free reagents, including for new organismal systems, and valid test data, appropriate for a commercial production path.

PHASE III: The widespread availability and use of cell-free systems will further enable the rapid engineering and optimization of biologically-based manufacturing platforms for the production of previously inaccessible technologies and products, and will facilitate the rapid prototyping of multi-pathway metabolic designs necessary for the engineering of complex biological systems. This will enable DoD to leverage the unique and powerful attributes of biology to solve challenges associated with production of new materials, novel capabilities, fuels, and medicines, while providing novel solutions and enhancements to military needs and capabilities. The successful development of reliable and distributable cell-free platforms for rapidly prototyping biological systems will have widespread applications across the biotechnology and pharmaceutical industries including rapid, optimized production of high value chemicals, industrial enzymes, diagnostics, and therapeutics. These cell-free platforms will be impactful for industrial biotechnology and pharmaceutical firms, as well as government and academic research-scale operations.

REFERENCES:

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3. Noireaux V, Maeda YT, Libchaber A. Development of an artificial cell, from self-organization to computation and self-reproduction. Proc Natl Acad Sci USA. 2011 Mar 1; 108(9): 3473-80

4. Siegal-Gaskins D, Tuza ZA, Kim J, Noireaux V, Murray RM. Gene circuit performance characterization and resource usage in a cell-free 'breadboard'. ACS Synth Biol. 2014 Jun 20; 3(6): 416-25

5. Sun ZZ, Yeung E, Hayes CA, Noireaux V, Murray RM. Linear DNA for rapid prototyping of synthetic biological circuits in an Escherichia coli based TX-TL cell-free system. ACS Synth Biol. 2014 Jun 20; 3(6): 416-25

KEYWORDS: Bioengineering, Biomanufacturing, Biotechnology, Cell-Free Production Systems, TX-TL, Lysate, Synthetic Biology, Genetic Engineering, Biology, Molecular Biology, In Vitro

TPOC: Dr. Elizabeth Strychalski
Phone: (571) 218-4620
Email: elizabeth.strychalski@darpa.mil

2nd TPOC: Dr. Daniel Wattendorf
Phone: (703) 526-4085
Email: daniel.wattendorf@darpa.mil

SB152-002 TITLE: Cortical Modem Systems Integration and Packaging

PROPOSALS ACCEPTED: Phase I and DP2. Please see the DARPA 15.2 Direct to Phase II solicitation instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREAS: Biomedical, Electronics

OBJECTIVE: Design and fabricate Cortical Modem electro/optical systems that demonstrate low-power telemetry of neural data and power across the scalp, skull, and brain tissue using standard data protocols. The system should be integrated within a single state-of-the-art system-on-a-chip scale implantable package suitable for use in humans.

DESCRIPTION: The DoD has a critical need for breakthrough medical therapies to treat wounded warriors with multiple comorbidities of sensory organs. This topic seeks to integrate state-of-the-art electronics, packaging, and passivation technologies with the latest low-power data and power delivery semiconductor components in a single package. In other words, DARPA seeks to wirelessly bridge cortical neural activity sensing components within the skull to external computing and network systems, designing an effective "Cortical Modem" that connects human brains to computer equipment and networks in a direct analogy to early telephonic modems, which connected computers to the ARPANET.

DARPA is open to a multiplicity of system architectures that, first and foremost, demonstrate significant improvements in the scale of neural channel bandwidth from the current 100-signal demonstrations, but secondly, may span a wide spectrum of implementation strategies from high-bandwidth transmission systems with limited implantable computation capability, to implantable integrated analysis and compression systems coupled to a limited bandwidth telemetry systems.

Significant advances in the miniaturization and ever lower-power performance of electronic and photonic technologies have enabled critical developments in miniaturized communications products like cellular phones. However, the time lag between such advances and their adoption in the fields of neuroscience and neuro-engineering has, in many cases, grown to more than twenty years. With such large interface

component feature sizes characteristic of the older technologies in common experimental use, the supporting interface electronics have now become one of the most significant and fundamental limits to their integration within human and animal bodies. For example, the Utah array features a 400 micrometer electrode pitch, a limitation compounded by the wet etch microfabrication technology available to the manufacturer. Note that this 400 micron feature size is representative of 1980s CMOS technologies, and is too coarse for interfacing with, for example, the visual cortex where neural pitch ranges from ten to thirty microns. As the mobile computing industry continues to push miniaturization, functionality, and power-consumption requirements to their limits, so too is the field of neuroscience pushing ever closer to full-duplex single-neuron scale interfaces. With focused technology development and integration to build a Cortical Modem, the necessary critical electronics and packaging could be leveraged across the entire academic and corporate neuroscience ecosystem to result in dramatically accelerated advances in science and commercialization of neuroscience technologies.

The goal of this topic is to develop cortical modem components that substantially improve the scale of signal transduction from the current 10x10 electronic probe arrays, as well as the scale of telemetry delivery of those signals., For reference purposes, one mm^3 volume of cortical tissue encloses approximately 100,000 neurons indicating an eventual need to both transduce and deliver wireless telemetry for as many as 10^7 independent neural channels. Proposals should target the design and implementation of a COTS-based full duplex cortical interface component. Essential elements of this component include flexible direct electronic interfaces to neural activity, sensors and low power pre-processing circuitry to convert and encode neural sensor signals into formats that can be transmitted wirelessly across the skull, wireless telemetry suitable for safe use in humans, and power delivery electronics. Packaging must leverage state-of-the-art miniaturized single system-on-a-chip ceramic packaging that incorporates on-board wireless power reception and conditioning circuitry.

Critical to the design of the system is a careful power and link budget analysis to account for relevant FDA and FCC regulations. In addition, proposals should detail the intended components (i.e. make, model, and part numbers), their interface design, and the technical and mechanical specifications that will ultimately yield the lowest power, smallest form-factor, highest signal-to-noise ratio and bandwidth system possible using COTS components. Critical systems integration challenges must be addressed explicitly in the proposal. Technical challenges and considerations include system power, transmission bandwidth, frequency and data rates, transmission protocols, optical wavelengths, etc. Offerors are to first uncover and understand the critical integration challenges that may limit the translation and commercial-viability of full-duplex cortical interfaces, and second to push the standards of integration by producing a first generation of truly miniaturized and implantable interface componentry, thereby accelerating innovation across the entire field of neuro-engineering.

Industrial and military collaborators should then produce products and reach their first commercialization milestones on a similarly accelerated timeline. Technical challenges may include:
• The development of a standard interface between a multiplicity of different neural sensing components and the data collection and transmission system.
• Maximizing the scalability and bandwidth-power product of both the internal neural sensing and external wireless data and power interfaces, but doing so within safe heat dissipation limits of the outer cortex and skull.
• The potential need for data translation and encoding components to minimize power requirements for transcranial data and power delivery.
• Establishing optimal trade-offs between physical, electronic, and data transmission specifications required to minimize the componentry bill of materials (BoM) and hence the size of the device that needs to be implanted.
• Sourcing state-of-the-art packaging and system-on-a-chip prototyping support
• Determining optimal bio-material passivation strategies and packaging materials limitations.

• Determining optimal power-bandwidth tradeoffs and scalability to support increasing sensory density, resolution, and sensitivity limitations.

PHASE I: Explore and determine the fundamental systems integration and packaging limitations (that are common across the entire neural interface field) in implementing a full-duplex read/write neural interface system that bridges data and power delivery across the human skull.

Phase I deliverables: 1) Final Report that identifies the neural read/write signals modalities (not necessarily required to be the same); details the technical challenges relevant to the read and write signals within the deployment environment; quantifies the information limits to the system relative to the information input/output of the cortical area of interest; details component-level metrics for coping with the data and power requirements; describes integration process, system-level challenges; and a thorough business plan describing the NRE costs, minimum rate of production, units per year required to achieve sustainable production of a cortical modem, and market analysis; 2) Develop a fully-operational proof-of-concept demonstration of the key components and functional systems in a bench-top / PC-board scaled prototype along with all the design documents and complete specifications, along with documentation of committed sources and service providers for the fabrication of the ultimate integrated system-on-a-chip Cortical Modem device to be produced in Phase II; full specifications and a complete BoM are required, itemizing each component and system that comprises the final prototype system. These demonstrations should be performed in relevant in vitro environments analogous to the final deployment environment in the human skull and cortex.

PHASE II: Development, demonstration, and delivery of a working fully-integrated cortical modem at a 1:1 physical scale with the underlying neurons. The Phase II demonstration should operate within a physical simulacrum that mimics as closely as possible the electrical and mechanical properties of human cortex, skull, and scalp. The integrated system should leverage COTS silicon and electro-optical devices wherever possible, and form a data and power bridge between the internal cortex and external machines. On the cortex side, a modular neural interface architecture should support bi-directional communications through a multiplicity of neural probe modalities, including, but not limited to, optical, electronic, and bio-molecular sensing interfaces. The external interface should be comprised of a wireless interconnection through intervening brain and skull tissue to external computing systems.

Proposers are encouraged to adapt modular componentry strategies that are generalizable to a wide range of neural interfaces. The Cortical Modem system should be able to collect and transmit neural signals through the skull in a complete, implantable package. It will have a form-factor and packaging that can be implanted in the cortex with core system functionality provided by COTS semiconductor components in a single ceramic system-on-a-chip package, rather than a fully-customized chipset.

The Phase II final report shall include (1) full system design and specifications detailing the electronics and proof-of-concept neural interfaces to be integrated; (2) expected performance specifications of the proposed components in vivo; and (3) calculations of energy and link budget scalability to larger cortical regions.

PHASE III: Breakthrough medical treatments for wounded warriors with multiple comorbidities of the sensory organs. Effective restoration sight, sound, smell, and vestibular sensation after massive head trauma. Breakthrough medical treatments for upper spinal cord injuries, enabling restoration of motor and sensory capability. Breakthrough medical treatments for diseases of sensory organs, providing sight and sound to treat indications not possible through use of current retinal prostheses and cochlear implants.

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KEYWORDS: neurotechnologies, cortical, systems integration, optical, transduction, in vivo, brain-machine interfaces, photonic, prototype

TPOC: Dr. Phillip Alvelda
Phone: (571) 218-4671
Email: phillip.alvelda@darpa.mil

SB152-003 TITLE: Broadband Self-calibrated Rydberg-based RF Electric Field and Power Sensor

PROPOSALS ACCEPTED: Phase I and DP2. Please see the DARPA 15.2 Direct to Phase II solicitation instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a Rydberg-based broadband (1 GHz – 1 THz) self-calibrated electric field sensor, power sensor, or components with high-sensitivity capable of working in a strong electric field environment (>1 kV/m). The electric field-sensing device should also be capable of imaging sub-wavelength RF fields to verify and guide circuit and metamaterial design achieving better than 10 µm spatial resolution.

DESCRIPTION: There is a critical need for capabilities that will enable the DoD to have self-calibrated electric field and power sensors in the RF, microwave, and millimeter-wavelength regimes. This topic seeks the demonstration of a portable broadband (1 GHz – 1 THz) electric field, power sensor, or key components towards a device. The sensor should be capable of operating in greater than 1 kV/m electric fields as to be usable for high-energy DoD applications. The electric field and power measurements must be SI traceable to remove the need for the recalibration process. Furthermore, the electric field-sensing device should be capable of sub-wavelength imaging of RF electric fields with spatial resolutions exceeding 10 µm. Many DoD and commercial applications critically rely on using calibrated electric field and power sensors in the RF, microwave, and millimeter-wavelength regimes. Currently no self-calibrated sensor exists in the 100 GHz – 1 THz frequency band. Typical detectors in the sub-THz frequency range are antennas which inherently perturb the field they are trying to sense, resulting in greater than 5% measurement errors.

Antennas have the further limitation that they are narrow-band detectors. A SI-traceable sensor in the 1 GHz – 1 THz range would remove the need for costly recalibration of older devices and would replace many narrow-band antennas with a single low-SWaP device in a handheld package. Quantum sensors based upon Rydberg atoms offer the potential of traceable calibration, high sensitivity, wide spectral coverage, and high power capability.

In addition to DoD applications, a Rydberg field and power sensor would have numerous commercial applications: circuit design [1, 2], biological sensing [3], aeronautics applications [4], and mobile communication [5]. This technology would not only verify circuit design but inform it by employing sub-wavelength RF field imaging of the complicated electronic fields from various dense circuits and metamaterials [1, 2]. Current technology employing electromagnetically induced transparency (EIT) in Rydberg atoms in an atomic vapor cell is a promising route but requires further development in order to achieve DoD functionality. These devices function by converting an electric field amplitude into a measurable frequency splitting [6] that is SI-traceable [7]. The electric field magnitude E is given by $|E|=\hbar\Delta f/P$, where $\hbar$ is Planck's constant divided by 2π, Δf is the measured frequency splitting, and P is the transition dipole moment. Current work has demonstrated sensitivities of 3 μV/sqrt(Hz) measuring electric fields as low as 7.3 μV/cm [8] and up to 40 V/m [9] in a 1-130 GHz frequency range. These results are the first calibrated field measurements in the 100 GHz – 1 THz frequency band to date. Employing this technique to image RF electric fields resulted in sub-100 μm spatial resolutions [1] for electric fields with frequencies up to 104 GHz [2, 10].

The fabrication of micrometer-sized vapor cells is one of the more challenging technological developments necessary for these sensors. The size of these vapor cells must be reduced to at least one quarter of the length of the minimum wavelength of interest in order to prevent variations in the measured RF fields produced by standing waves. These cells must be all dielectric, made of quartz or Pyrex for example, and must be filled with alkali atoms such as Rb and Cs or a mixture of atomic species. The fabrication of micrometer-sized vapor cells suffers from atomic adsorption to the cell walls. These vapor cells must employ a mitigation technique for the reduced vapor pressure such as novel coatings or materials, bonded infrared absorption glass to the outside of the cell for IR heating or optical coupling mirrors bonded to the cell to form optical resonators for enhanced atom-light interaction. Such vapor cell production would not only benefit electric field sensing but atomic vapor-based magnetometry. Atomic vapor magnetometry currently provides the most sensitive magnetic field measurements [11] but it does not have high spatial resolution because it is limited to integration over the vapor cell length. Commercially available micrometer-sized atomic vapor cells would allow for the extension of atom-based magnetometry into a different spatial resolution regime [12, 13].

PHASE I: Demonstrate the operation of key components towards the electric field or power sensor in a laboratory setting such as: broadband measurements (100-250 GHz), electric field sensitivities better than 100 μV/cm, circuitry imaging with better than 50 μm spatial resolution, or fabrication of an alkali vapor cell with sub-mm length scales, and the development of a technique to mitigate reduced vapor pressures. Phase I deliverables include a final report that documents the results of each demonstration and design concepts to extend the measurement space to 1 GHz - 1 THz, improve the spatial resolution, and detail an experimental method to use the device in a high electric field environment (greater than 1 kV/m).

PHASE II: Construct and demonstrate a breadboard system with a path towards a portable device. If the performer is developing components, fabricate the miniaturized alkali vapor cell to less than a 100 μm length.

Phase II deliverables: 1) a demonstration in a simulated or relevant environment achieving broadband measurement (1 GHz – 1 THz), detection of less than 1 μV/cm electric fields, and sub-wavelength imaging with better than 10 μm spatial resolution. 2) a final report that documents the results of the demonstration and specifications of the fabricated alkali vapor cell 3) Completed designs for a portable prototype. This phase is expected to reach TRL 5.

PHASE III: If successful this technology could transition to multiple DoD offices and could eventually replace current 1 GHz – 1 THz based electric field and power sensors, removing the need for recalibration against standards. This device could also be commercially viable to examine densely packed microwave

circuit designs imaging the electric fields with sub-100 μm resolution to strongly inform and guide circuit design. Development of the micrometer-sized alkali-based vapor cells would be commercially usable for atomic vapor-based magnetometry opening new realms of spatial resolution for the highest magnetic field sensitive magnetometers. Such vapor cells could also have potential use in the timing community.

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KEYWORDS: atomic sensor, Rydberg, EIT, vapor cell, self-calibrated, RF, microwave, millimeter-wave, directed energy

TPOC: Dr. James Gimlett
Phone: (703) 526-2874
Email: james.gimlett@darpa.mil

SB152-004 TITLE: Many-Core Acceleration of Common Graph Programming Frameworks

PROPOSALS ACCEPTED: Phase I and DP2. Please see the DARPA 15.2 Direct to Phase II solicitation instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop next-generation many-core acceleration capabilities for current leading edge graph programming ecosystems such as Tinkerpop, GraphLab, and GraphX, deployable on modern massively parallel architectures such as GPU-accelerated systems, to facilitate ease of integration and lower barriers to adoption of many-core technologies.

DESCRIPTION: Today there is a DoD need for graph analytics capabilities, which are critical for a large range of application domains with a vital impact on both national security and the national economy, including, among others: counter-terrorism; fraud detection; drug discovery; cyber-security; social media; logistics and supply chains; e-commerce, etc. Widely used graph development frameworks have enabled online (but not real-time) graph analytics for broad classes of problems at a modest data scales and support only offline analytics for very large data scales. The Facebook graph today has over 1 Trillion edges. A single iteration of a graph traversal takes up to 3 minutes using Apache Giraph on 200 commodity CPU servers. A full breadth first traversal of the graph could take nearly 20 minutes, and algorithms that relax to a solution can require 50-100 iterations, implying that it could take several hours to compute the Page Rank of the Facebook graph.

Bringing analytics within these graph programming frameworks into real-time on large graphs requires that they be able to leverage the computing advances in multi-core platforms. However, scalable, data-parallel graph analytics on many-core hardware is a fundamentally hard problem that goes well beyond the current state of the art. Graph data models and algorithms are used for network structured data, when the data are poorly structured, or when complex relationships must be drawn from multiple data sets and analyzed together. Graph operations are inherently non-local and, for many real-world data sets, that non-locality is aggravated by extreme data skew.

Graph analytics are data intensive rather than compute intensive which means that memory and network bandwidth are the bottlenecks for graph processing. Overall, current solutions applied to scaling graph frameworks such as Tinkerpop and Graphlab do not have all of the desired attributes integrated, specifically 1) Solutions based on map/reduce or requiring checkpoints to disk are 1000s of times too slow to extract the value latent in graphs for time-sensitive analytics. (2) Solutions based on non-updatable data representations are limited in their application to complex analytics. 3) Solutions that provide robust scaling and high performance require specialized programming techniques that are not

easily accessible to the existing graph development community. Approaches leveraging multi-core technology have significant promise. At the purely hardware level, GPU memory bandwidth is set to jump by 4x by Q1 2016 (Pascal). This should provide a 4x speedup. Thus going from 10x - 100x speedups over CPUs to 40x - 400x over CPUs.

PHASE I: Develop innovative approaches to apply many-core GPU and/or hybrid CPU technologies to existing graph development APIs. The focus should be on framework fidelity, computational scalability, and easing the burden of integration. In addition, develop detailed analysis of predicted performance of the proposed approach and plans for developing the approach into a comprehensive platform to accelerate a graph framework in Phase II. The Phase I deliverable is a final report documenting the effort and results.

PHASE II: Develop a comprehensive implementation of an existing graph framework accelerated for commodity high performance many-core (GPUs) and multi-core CPUs technologies using the approaches identified in Phase I. Develop a prototype and establish a preliminary benchmark using various standard problems, and apply the tool to a DoD relevant problem. Phase II deliverables will include software, a final report documenting the effort, a document describing the architecture and a user's manual.

PHASE III: Real time data ingest and reasoning analytics for military situational awareness platforms. Commercial uses of the accelerated graph framework include a 1000-10000X acceleration of existing graph analytics such as Facebook's current graph traversal.

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http://sourceforge.net/projects/mpgraph/files/

2. http://www.stingergraph.com (Sourcecode – BSD derivative license)
https://github.com/robmccoll/stinger

KEYWORDS: PlanX, XDATA, Cyber operations, Cyber, situational awareness

TPOC: Mr. Frank Pound
Phone: (571) 218-4344
Email: frank.pound@darpa.mil

SB152-005 TITLE: Ovenized Inertial Micro Electro Mechanical Systems

PROPOSALS ACCEPTED: Phase I

TECHNOLOGY AREAS: Sensors, Battlespace

OBJECTIVE: Develop temperature stabilization and packaging of MEMS inertial sensors with consistent tactical grade performance across the operating range of -40C to +85C.

DESCRIPTION: There is a critical DoD need for capabilities that focus on temperature stabilization of MEMS inertial sensors to improve bias and scale factor stability. Military operations rely on satellite-based Global Positioning System (GPS) for precision Positioning, Navigation & Timing (PNT) information. However, GPS is an extremely small signal, which may be degraded due to signal interference or obstructed by environmental factors such as clouds, urban canyons or other impeding

structures [1]. In GPS-degraded environments critical PNT information must be gathered from alternate sources, such as navigation by the technique of dead reckoning based on acceleration and rotation inputs from an Inertial Measurement Unit (IMU) [2]. IMUs based on Micro Electro Mechanical Systems (MEMS) are low Cost, Size, Weight, and Power (CSWaP), but typically exhibit high calibration environmental sensitivity, particularly to external temperature variation [3,4]. MEMS sensors are early in their development; they have made their way into consumer market but underlying limits to sensitivity and stability are not well understood. This is analogous to the development of crystal oscillators (XO) developed early in the 20th century.

Over the past century, temperature sensitivity of crystal oscillators has been improved by applying temperature compensation algorithms based on the externally sensed ambient temperature (TCXO) [5]. However, the best performing crystal oscillators rely on ovenization of the resonant device to provide the highest stability (OCXO)[6]. The evolution of MEMS-based inertial sensors is likely to follow a similar trajectory due to the similarity of vibrating MEMS devices to quartz oscillators. At present, uncompensated MEMS inertial sensors are widely available for commercial applications and digital temperature compensation (TC-MEMS) devices are emerging [7]. Temperature stabilization has been demonstrated to improve long-term stability and reproducibility of MEMS inertial sensors in an academic setting but has yet to be transitioned into marketable MEMS-based inertial sensors [8]. This SBIR seeks to develop Ovenized Inertial MEMS (OI-MEMS) with a viable path to commercialization.

PHASE I: Design a concept for achieving tactical grade inertial sensor performance, as listed below. The sensor should operate on 500mW in a 0.5cc package. Phase I deliverables will include: a fabrication flow process, and a detailed analysis of predicted performance metrics. Bias Stability over temperature (-40 to +85°C)
- Gyroscope: 1°/hr
- Accelerometer: 1 mg Scale Factor Stability over temperature (-40 to +85°C)
- Gyroscope: 10 ppm
- Accelerometer: 1 ppm ARW
- Gyroscope: 0.125°/rt(hr)
- Accelerometer: .5 ft/s/rt(hr)

PHASE II: Develop, demonstrate, and validate Phase 1 model predictions; refine fabrication procedures to fine tune thermal expansion and coefficient second-order effects; conduct life cycle and environmental testing to verify performance; manufacture and deliver gyroscope or accelerometer prototypes for government evaluation. Required Phase II deliverables include 5 packaged sensors with necessary electronics to operate the Ovenized Inertial MEMS device.

PHASE III: The military need for PNT information in the absence of GPS is in very high demand. Current DARPA programs are pursuing self-contained navigation for applications such as missile guidance, mounted and dismounted soldier navigation in GPS denied environments. Much progress has been made in existing microPNT programs. This SBIR will complement those efforts, by addressing the key driver of long-term instability with a fast track to commercialization. Due to the high performance of the OI-MEMS, there is limited commercial application. However, there is a market for high performance, small CSWaP inertial sensors for oil drilling and agricultural applications.

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KEYWORDS: MEMS, Ovenized, Inertial Sensors, PNT, gyroscopes, accelerometers, temperature control

TPOC: Dr. Robert Lutwak
Phone: (703) 526-2863
Email: robert.lutwak@darpa.mil

SB152-006 TITLE: Compact, Configurable, Real-Time Infrared Hyperspectral Imaging System

PROPOSALS ACCEPTED: Phase I and DP2. Please see the DARPA 15.2 Direct to Phase II solicitation instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: Develop and demonstrate a re-configurable, real-time portable infrared hyperspectral imaging system. This capability should have the ultimate utility in detection and identification of critical targets in complex, highly variable backgrounds.

DESCRIPTION: There is a compelling DoD need to create a low cost, compact and reconfigurable infrared imaging spectrometer that can operate in real time, and in a variety of backgrounds and ambient conditions. Hyperspectral imaging (HSI) systems have been fielded for the detection of hazardous chemical and explosives threat materials, tag detection, friend vs. foe detection (IFF) and other defense critical sensing missions. Such systems currently exist in airborne and ground sensing configurations in short-wave, mid-wave and long-wave infrared (IR) spectral regions. They are based on HSI sensor hardware architectures combined with multivariate analysis algorithms [1,2]. While these imaging systems can provide sensitive and specific detections of targets and identification of materials in complex backgrounds, they are typically large, costly to field, operate, and support, and generally do not operate in real-time. Those systems that operate in real time typically compromise some degree of freedom, such as the number of spectral bands, image definition, or number of targets being detected. Reconfiguring the system to an alternative set of targets or backgrounds requires significant effort, which makes adjusting to dynamic mission conditions impractical. Nonetheless, intelligence based on HSI systems has proven very

useful, resulting in an increasing demand for it; but due to the high cost of procuring and maintaining an HSI system, they are only available to privileged users.

Specifically, what is needed is an IR hyperspectral imaging and sensing capability with the following characteristics: (1) rapidly field-configurable operation to adapt to different targets or operating conditions; (2) real-time, target on-the-move operation, ideally at the frame rate of the focal plane array camera; (3) real-time automated target signature detection, performed within the system to dramatically reduce data bandwidth, downlink transmission bandwidth requirements, and post-processing; (4) significantly reduced cost, size, and weight; and (5) imaging operation with minimal support infrastructure. The resulting system should be able to support one or more of the following missions: counter IED detection, IFF, bio/chemical WMD detection and tag, track and locate (TTL) missions.

The performance goals of such a system are:
• Frame rate 10 frame per second (fps) or greater
• Free spectral range covering at least one band of 850-1700 nm for SWIR, 3-5μm for MWIR, 8-11+μm for LWIR
• Form factor, suitable for operation as a handheld, wearable or UAV-mounted configuration
• Weight less than 5 lbs.
• Run time greater than 4 hours, with power source included in weight metric
• Cost of less than $50,000 in volume of 1000 or more
• High Definition Chemical Image - Megapixel (1Kx1K) or greater
• Low latency of less than or equal to 100ms
• Interface compatible with XML schema
• Autonomously link to existing military architecture or infrastructure (e.g., cell phone).

In summary, a Compact, Mission-Configurable, on-Demand, Real-Time, Infrared Hyperspectral Imaging Sensor is envisioned. It is acknowledged that all spectral ranges may not be accommodated in a single sensor, and that the objective vision may not be fully realizable during the course of a Phase II SBIR. However, concrete and compelling hardware/software progress towards this vision is expected to be demonstrated.

PHASE I: Design a concept for an infrared hyperspectral imaging system capable of real-time, and multi-mission configurable-on-demand operation with specific performance objectives as described. Develop an analysis of predicted performance, and define key component technological milestones. Establish performance goals in terms of parameters such as time of operation; probability of detection and false alarm; detection time; spectral range; image quality; field of view; day, night and obscured condition visualization; image frame rate; and size, weight and power (SWaP). In addition, provide a contrast with existing hyperspectral imaging systems. Produce an initial mockup, possibly using 3D printed parts and/or solid models, showing the system form factor at the preliminary design level.

Phase I deliverables would include:
• A description of the system design and functions mapped to real-time imaging system requirements,
• A performance assessment against existing approaches,
• An evaluation of key tradeoffs, and
• A risk reduction and demonstration plan.
• Final report/phase II proposal

PHASE II: Develop and demonstrate a prototype real-time mission-configurable infrared hyperspectral imaging sensor system with the specified features, including on board detection, and operation at 10 fps or higher sampling rate. Construct and demonstrate the operation of a laboratory prototype, which would have the core features needed to achieve mission configurability capabilities. Exercise relevant software

functions and exposure to different mission conditions, including demonstration of ability to change system detection configurations against multiple different target sets through rapid field configuration. Perform additional analyses as needed to project eventual performance capabilities.

Phase II deliverables would include:
• A final design with all drawings, simulations and modeling results;
• One prototype of the real-time chemical imaging system; • Software applications as needed;
• Performance data compared with performance and environmental goals; and
• Schedule with financial data for program execution.
• Preliminary and critical design reviews
• Monthly reports

PHASE III: As described above, the military utility of the data and intelligence that is generated by the current large and costly systems has been demonstrated. Driving the SWaP and cost down such that the system can be used by a dismount or on a small UAV will enable proliferation of the capability in the same way that night vision goggles or cell phones have become an integral part of the soldier's arsenal. Requiring the system to be compatible with existing systems and data formats will help ensure more rapid acceptance and use. Commercial application of hyperspectral imaging has been increasing in parallel to military applications. These include agriculture, mining, medical imaging and diagnoses, environmental management, disaster management and hazard assessment. Like military applications, the cost and size of these systems limits their availability to all but the most privileged users. Driving the system cost and SWaP down would enable proliferation of these devices to a potentially large user base, including municipalities (police, fire, etc.), agriculture (farmers, land managers, etc.), and healthcare (health screening and microbiology).

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KEYWORDS: Hyperspectral; infrared; real-time; spectrometer; handheld; counter IED; unmanned aerial vehicle; UAV

TPOC: Dr. Jay Lewis
Phone: (703) 248-1536
Email: jay.lewis@darpa.mil

2nd TPOC: Ryan Close
Phone: (703) 704-3123
Email: ryan.r.close.civ@mail.mil

SB152-008 TITLE: Low Cost Expendable Launch Technology

PROPOSALS ACCEPTED: Phase I

TECHNOLOGY AREAS: Space Platforms, Weapons

OBJECTIVE: Leverage emerging commercial entrepreneurial and defense technologies enabling lightweight, high-specific-energy liquid-rocket technology. Develop the design, manufacturing and test approach for fabricating extremely low-cost, high propellant mass fraction launch vehicles and upper stages for space access. Critical component or analytical risk reduction is encouraged.

DESCRIPTION: There is a compelling DoD need to leverage emerging commercial entrepreneurial and defense technologies enabling lightweight, high-specific-energy liquid-rocket technology. Many established aerospace and emerging entrepreneurial companies are developing new rocket stage technologies that promise to reduce the cost of access to space. The goal of this topic is to leverage these investments to enable low-cost launch vehicles that minimize gross and dry weight while maximizing the propellant load, engine specific impulse and/or payload. Technological trends facilitating such lightweight stages include an ongoing computer/software revolution enabling affordable design, sophisticated software in lieu of mechanical complexity, integration, and test; micro-miniaturization of electronics and mechanical actuators; high strength-to-weight composites and nano-engineered materials; lightweight structural concepts and thermal protection; advanced manufacturing methods, high thrust/weight rocket engines and turbo-machinery; and novel high-density-impulse liquid propellants that are safe, cheap and easy to handle.

The offeror must demonstrate a clear understanding of the system applications of the launch vehicle and the supporting technologies. A system application of interest to the government is modifying the launch vehicle as a low-cost upper stage for DARPA's Experimental Spaceplane (XS-1) program. Key design goals include balancing low gross mass with adequate velocity change, payload and manufacturing cost. Additionally, reusable launch concepts such as XS-1 may carry stages through either normal or longitudinally-oriented hardpoints/racks.

Stages with efficient structural arrangements to cope with such load paths while remaining low in mass and cost are of interest. Other potential system applications include a wide range of commercial launch vehicles, tactical missiles, satellite integral propulsion and future boost-glide tactical or air transport systems. Similarly, a clear understanding of the technology applications to XS-1 as well as other proposed military and commercial systems is also essential.

Critical technologies could include lightweight structures and propulsion, high-density-impulse propellants, miniaturized avionics, modular components, altitude compensation and complementary aerodynamic/propulsion integration, and stability, guidance and control subsystems all integrated into the stage while keeping the system simple and affordable. Offerors may seek to design and fabricate an entire stage or only critical subsystems.

PHASE I: Develop the design, manufacturing and test approach for fabricating extremely low-cost, high propellant mass fraction launch vehicles and upper stages for space access. Critical component or analytical risk reduction is encouraged. Identify potential system level and technology applications of the proposed innovation. Although multiple applications are encouraged, to help assess the military utility the proposed stage should be useful as an upper stage on the XS-1 experimental spaceplane. The stage(s) must be designed to support: 1) an ideal velocity change of up to 20,000 fps objective, 2) a payload of 3,000 lbs, 3) a gross mass of less than 30,000 lbs, 4) a unit fly away cost of <$1M per stage, and 5) a safe and affordable alternative to today's carcinogenic propellants such as hydrazine, unsymmetrical dimethylhydrazine and red fuming nitric acid.

PHASE II: Finalize the Phase I design, then develop, demonstrate and validate the system design, critical hardware components and/or enabling technologies. Design, construct and demonstrate the experimental hardware or component prototypes identified or developed in Phase I. The Phase II demonstration should advance the state of the art to between Technology Readiness Level 5 and 6. Required Phase II

deliverables will include the experimental prototype hardware and a final report including design data such as CAD and detailed mass properties, manufacturing and test plan, costing data, test data, updated future applications and Phase III military transition and commercialization strategies.

PHASE III: The offeror will identify military applications of the proposed innovative technology(s) including use as a low-cost upper stage on the XS-1 experimental spaceplane. Leveraging of commercial and defense stages tailored to support specific upper stage needs is encouraged. Technology transition opportunities will be identified along with the most likely path for transition from SBIR research to an operational capability. The transition path may include use on commercial launch vehicles or alternative system and technology applications of interest to operational military and commercial customers.

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3. http://en.wikipedia.org/wiki/List_of_private_spaceflight_companies, Listing of robust commercial spaceflight industry members.

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KEYWORDS: Upper stage, commercial launch, XS-1, point to point, ballistic, transport, suborbital, flight, rocket, space, airlift, boost glide and propulsion.

TPOC: Mr. Jess Sponable
Phone: (571) 218-4251
Email: jess.sponable@darpa.mil

2nd TPOC: Bruce Thieman
Phone: (937) 656-8779
Email: Bruce.Thieman@us.af.mil