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

Offerors responding to DARPA topics listed in this Announcement must follow all instructions provided in the DoD Program Announcement AND the supplementary DARPA instructions contained in this section.

IMPORTANT NOTE REGARDING THESE INSTRUCTIONS: These instructions only apply to proposals submitted in response to DARPA 17.1 Phase I topics.

DARPA is conducting a "Direct to Phase II" (DP2) pilot implementation for this 17.1 SBIR Announcement. Not all DARPA topics are eligible for a DP2 award. Potential offerors should refer to the 17.1 DARPA Topic Index to review proposal types accepted against each topic and read the topic requirements carefully. Please see the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

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 (SBPO).

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Attention: DIRO/SBPO
675 North Randolph Street
Arlington, VA 22203-2114
sbir@darpa.mil
http://www.darpa.mil/work-with-us/for-small-businesses

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 17.1 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 in communication retrieval and contract negotiation (if selected).

Notification of Proposal Receipt

Within 7 business days after the announcement 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 announcement 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 Announcement.

Debriefing

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

Announcement Protests

Protests regarding the **Announcement** should be submitted in accordance with the DoD Program Announcement section 4.11.

Protests regarding the **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

Discretionary Technical Assistance (DTA)

DARPA has implemented the Transition and Commercialization Support Program (TCSP) to provide commercialization assistance to SBIR and/or STTR awardees in Phase I and/or Phase II. Offerors awarded funding for use of an outside vendor for discretionary technical assistance (DTA) are excluded from participating in TCSP.

DTA requests must be explained in detail with the cost estimate and provide purpose and objective (clear identification of need for assistance), provider's contact information (name of provider; point of contact; details on its unique skills/experience in providing this assistance), and cost of assistance (clearly identified dollars and hours proposed or other arrangement details). 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).

Offerors proposing DTA must complete the following:

1. Indicate in question 17 of the proposal coversheet, 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.

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

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.

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. 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.

This is intended to replace the instruction in section 5.4(c.)(6) of the DoD Announcement.

The Phase I commercialization strategy shall not exceed 5 pages, and will NOT count against the 20-page proposal limit. It should be the last section of the technical volume and include the following elements:

1. Problem or Needs Statement. Briefly describe the problem, need, or requirement, and its significance relevant to a DoD application and/or a private sector application that the SBIR project results would address.
2. Potential Product(s), Application(s), and Customer(s). Identify potential products and applications, DoD end-users, Federal customers, and/or private sector customers who would likely use the technology. Provide specific information on the market need the technology will address and the size of the market.
3. Business Model and Funding. Include anticipated business model; potential private sector and federal partners the company has identified to support transition and commercialization activities; and the Technology Readiness Level (TRL) expected at the end of the Phase I. Also include a schedule showing the quantitative commercialization results from this SBIR project that your company expects to achieve.
4. Preliminary Phase II Strategy. Include key proposed milestones anticipated during Phase II such as: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.

OPTIONAL:

- Advocacy Letters—Feedback received from potential Commercial and/or DoD customers and other end-users regarding their interest in the technology to support their capability gaps.
- Letters of Intent/Commitment—Relationships established, feedback received, support and commitment for the technology with one or more of the following: Commercial customer, DoD PM/PEO, a Defense Prime, or vendor/supplier to the Primes and/or other vendors/suppliers identified as having a potential role in the integration of the technology into fielded systems/products or those under development.

Advocacy Letters and Letters of Intent/Commitment are optional, do NOT count against any page limit, and should ONLY be submitted to substantiate any transition or commercialization claims made in the commercialization strategy. Please DO NOT submit these letters just for the sake of including them in your proposal. Letters that are faxed or e-mailed will NOT be accepted. Please note: In accordance with section 3-209 of DOD 5500.7-R, Joint Ethics Regulation, letters of endorsement from government personnel will NOT be accepted.

Phase I Proposal Checklist

A complete proposal must contain the following four volumes:

1. Volume 1: Cover Sheet.
    a. Complete and accurate.
    b. Base and option costs are proposed separately.
2. Volume 2: Technical Volume.
    a. Does not exceed 20 pages (not including the commercialization strategy or DTA). Pages in excess of the 20-page limit will not receive consideration during evaluation.
    b. Begins on page 1 and all pages of the proposal are numbered consecutively.
    c. Include documentation required for DTA (if proposed).
3. Volume 3: Cost Volume.
    a. Use 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 are clearly separated and identified in the Cost Volume.
    d. If proposing DTA, cost submitted in accordance with instructions
4. Volume 4: Company Commercialization Report
    a. Follow requirements specified in section 5.4(e) of DoD Instructions.
5. Submission
    a. Upload four completed volumes electronically through the DoD submission site by the announcement closing date.
    b. Review 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.
    c. Submit proposal before 6:00 A.M. on the announcement closing date.

Phase I Evaluation Criteria

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

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".

Phase II Proposal

All offerors awarded a Phase I contract under this announcement 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/work-with-us/for-small-businesses/participate-sbir-sttr-program for more information regarding the Phase II proposal process.

DARPA SBIR 17.1 Topic Index

*These instructions **ONLY** apply to **Phase I** Proposals. For Direct to Phase II, refer to the DARPA 17.1 Direct to Phase II (DP2) Topics and Proposal Instructions available at (http://www.acq.osd.mil/osbp/sbir/index.shtml).*

Proposals Types Accepted

Topic	Topic Title	Phase I	DP2
SB171-001	New Platforms for High-Throughput Culturing and Analysis of Microbial Communities	YES	YES
SB171-002	Automated Environmental and Biological Threat Identification System	YES	YES
SB171-003	New Platform Technologies for Viral and Therapeutic Evolution Assays	YES	YES
SB171-004	Applying Novel Materials and Fabrication Techniques to Thermionic Energy Conversion	YES	YES
SB171-005	Discovery	YES	YES
SB171-006	Code Interposition Framework for Mobile Cyber Applications	YES	NO
SB171-007	Modeling Human Dimensions of the Cyber Ecosystem	YES	YES
SB171-008	Harnessing Open-Source Signals for Detection of Systematic Intervention in Online Discourse	YES	YES
SB171-009	Force Protection in the Online Information Environment	YES	YES
SB171-010	Ultra-Compact Power Conditioning System for High Power RF Transmitters	YES	YES
SB171-011	Recommender Systems for Streaming Data Environments	YES	YES
SB171-012	Non-linear Adaptive Optics	YES	YES
SB171-013	Load Bearing Thermal Protection Structure for Hypersonic Flight	YES	YES
SB171-014	Adaptive Control and Advanced Sensing for Turbine Based Combined Cycle Vehicles	YES	YES
SB171-015	Spacecraft Identification Device	YES	NO

DARPA SBIR 17.1 Topic Descriptions

SB171-001 TITLE: New Platforms for High-Throughput Culturing and Analysis of Microbial Communities

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop and demonstrate novel, high yield, and high throughput multiplexed platforms for culturing and analysis of microbes from microbial communities.

DESCRIPTION: There is a critical DoD need to understand and precisely engineer microbial communities. Microbes hold promise as untapped sources of therapeutic molecules and may be leveraged for a range of industrial applications from medicine to mining. Better understanding of microbial communities would enable the manipulation of the diverse environments in which they are found. Microbial communities are increasingly appreciated as rich sources of natural products and rare metabolic activities, and as key contributors to the health and behavior of the ecosystems they inhabit. The microbial diversity of earth is estimated to be as high as 10^12 species, only 10^4 of which have been sufficiently characterized to be exploited for biotechnology. This relatively small sample of characterized species is in part due to the difficulty of cultivating most microbial species using standard culturing techniques. Technical challenges for culturing microbes include the need for specific growth environments, and a dependence of the microbes on community and host interactions, and minimal culture density. Recent successful efforts to cultivate "unculturable" species by closely mimicking natural environments in the lab have been tailored towards individual species and/or communities of interest. The positive results of these efforts illustrate the feasibility of increasing the number of cultivable species, but ultimately the approaches have been too ad hoc and labor intensive to keep pace with the growing demand for microbiome studies.

DARPA seeks general experimental platforms to enable the high-throughput cultivation and functional characterization of microbial communities from a wide range of environments. The proposed solution should increase the number of unknown species that can be separated, identified, and cultivated from microbiomes by three orders of magnitude relative to standard lab techniques, such as colony growth on petri dishes. The proposed technology should also facilitate analysis of microbial community interactions, such as metabolic contributions of individual species, host interactions, and environmental factors that influence community function and behavior. As such, the proposed technology should be compatible with standard analytical techniques used to study and identify microbial species, including but not limited to next generation sequencing, quantitative polymerase chain reaction (qPCR), mass spectrometry, fluorescence activated cell sorting (FACS), and fluorescent in situ hybridization (FISH).

PHASE I: Develop a breadboard system to demonstrate feasibility of approach for improving yield of culturable microbes. Evaluate performance of system with mock microbiome communities. Deliverables include a detailed design and manufacturing plan and a Phase I final report.

PHASE II: Develop a system prototype and demonstrate enhanced ability to separate, identify, and cultivate microbial species from microbiomes. Platform prototype performance will be evaluated with multiple environmental and microbiome samples and must demonstrate the ability to increase the number of culturable species by three orders of magnitude relative to traditional methods. Deliverables include three standalone prototype systems for independent government evaluation, performance test results, and a Phase II final report.

PHASE III DUAL USE APPLICATIONS: This platform has the potential to become broadly available to microbiology researchers in industry, government, and academia.

REFERENCES:

1. J. Bacteriol. 2012, 194, 4151-4160.

KEYWORDS: microbiome, microbiology, biotechnology, microbial communities, microbes

SB171-002 TITLE: Automated Environmental and Biological Threat Identification System

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical, Information Systems

OBJECTIVE: Develop a handheld platform for real-time identification of a wide range of insect, plant, and reptile (e.g., snake) species that may be found in DoD areas of operation.

DESCRIPTION: There is a DoD need to provide warfighters with tools to support identification of various environmental and biological threats that may be found in their areas of operation. Early identification of potentially harmful insects, plants, and reptiles in the surrounding environment could help to improve safety and maintain maximal physical health of DoD associated personnel. Among other things, such identification tools could help to stop or reduce disease outbreaks or infestations and direct warfighters away from poisonous plants such as the common Toxicodendron radicans (poison ivy). Complicating current efforts is the fact that the number of species of interest in a given area is immense, and even few experts have the necessary training to correctly identify all potential threats across varied geographic regions. There is no current lightweight, accessible, commonly-used solution to the identification problem.

This SBIR topic will support the development of an automated visual recognition and identification system that will (1) provide the image processing capability necessary for characterization of user-submitted pictures of insects, plants, and reptiles, (2) correctly identify dangers, and (3) provide users with relevant and sufficient information to allow for informed decision-making. Importantly, the image processing algorithms and information databases will be contained on a small (e.g., thumb-drive sized) device that interfaces directly with smartphones or similarly ubiquitous technology with image-acquisition capabilities, so that identification can take place on-the-spot in environments without internet connectivity. In addition to remote capability, devices will also wirelessly link to a public, web-accessible database that will synchronize with all devices in-the-field (when connections are available). The development of a master database of field-imaged data will be annotated by subject matter experts who can provide necessary information. As the databases grow with contributions from users, machine learning techniques will be used to improve the identification capabilities. Work in this area will benefit from recent advances in machine learning, image processing, and visual bioinformatics that allow for rapid and automated insect, plant, and reptile identification.

PHASE I: Create a small memory storage device that interfaces with common imaging-capable smartphones or similarly sized battlefield equipment, and an associated app that provides access to the device camera and read/write capability. Build the necessary infrastructure to support a web-accessible database of plant, insect, and reptile images. Ensure that the mobile app and storage device can synchronize with the master database. Demonstrate synchronizing capability by uploading/downloading images from/to various devices. Populate initial database with existing images from reputable university and museum collections. Create the necessary algorithms for image processing and demonstrate positive identification (>90% success rate) of plants, insects, and reptiles from additional high-quality complete photographs not in the original dataset. Establish what information would be relevant to users and provide in an easily distilled format. Phase I deliverables will include detailed designs of the memory storage device and a working prototype, app source code, algorithms, web-accessible curated database of plant, insect, and reptile images, and a final report that includes a detailed and clear description of the algorithms implemented, justifications for choices made with respect to user-relevant information, demonstration test data, and preliminary performance results.

For topic SB171-002 ONLY, DARPA will accept proposals for work and cost up to $225,000 for Phase I. The preferred structure is a $175,000, 12-month base period and a $50,000, 4-month option period. Alternative structures may be accepted if sufficient rationale is provided.

PHASE II: Expand the image library by compiling additional images taken from various locations. Create machine learning algorithms that improve the success rate to >95%. Demonstrate positive identification of the same sample species in a range of light conditions and backgrounds. Demonstrate successful identification using photographs of samples that are incomplete (e.g., insect samples with wings missing or legs broken). Characterize robustness of the device to various environmental conditions (e.g., heat, water). Required Phase II deliverables will include additional source code for machine learning algorithms and other software components added since Phase I, expanded database with geographic information included (if not previously), and a final report that includes description of any changes made to the database, demonstration of success rate improvement, and characterization of device performance in specified environmental conditions. Report should also include a discussion of the potential to expand the scope of the technology to cover fish, birds, and other wildlife that, due to their sensitivity to physical, chemical, and biological threats, may provide indicators to harmful environmental conditions.

PHASE III DUAL USE APPLICATIONS: A successful mobile platform for real-time insect, plant, and reptile species identification has significant potential to transition rapidly to the commercial sector for use in DoD and industrial applications. Users in various environments and in a wide variety of roles—including Environmental Science/Engineering Officers in the field—stand to benefit from the support such a platform will provide in assessing potential environmental and biological risks.

REFERENCES:

1. Larios, N., Deng, H., Zhang, W., Sarpola, M., Yuen, J., Paasch, R., ... & Shapiro, L. G. (2008). Automated insect identification through concatenated histograms of local appearance features: feature vector generation and region detection for deformable objects. Machine Vision and Applications, 19(2)

2. Sarpola, M. J., Paasch, R. K., Mortensen, E. N., Dietterich, T. G., Lytle, D. A., Moldenke, A. R., & Shapiro, L. G. (2008). An aquatic insect imaging system to automate insect classification. Transactions of the ASABE, 51(6), 2217-2225.

3. Wang, J., Lin, C., Ji, L., & Liang, A. (2012). A new automatic identification system of insect images at the order level. Knowledge-Based Systems, 33, 102-110.

4. Yang, H. P., Ma, C. S., Wen, H., Zhan, Q. B., & Wang, X. L. (2015). A tool for developing an automatic insect identification system based on wing outlines. Scientific reports, 5.

5. Additional Topic Briefing, November 30, 2016 (uploaded in SITIS on 11/30/16).

KEYWORDS: automated visual identification, insect identification, plant identification, medical entomology, pattern recognition, machine learning, bioinformatics

SB171-003 TITLE: New Platform Technologies for Viral and Therapeutic Evolution Assays

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Design and develop new bioreactor technology suitable for long-term assays of cellular and viral evolutionary dynamics, emulating human-like continuous conditions. Demonstrate and validate the technology in a relevant application.

DESCRIPTION: There is a critical DoD need to capture long-term evolutionary dynamics of viral mutations in the laboratory under human-like conditions to aid in the design of evolving therapies (See DARPA INTERCEPT program [1]) and to assess efficacy of these and traditional static therapies in an evolutionary environment. The state-of-the-art approach to tracking long-term viral dynamics is flask-based serial passaging, which continually transfers a small fraction of the viral output from a given flask of infected cells onto a new flask of uninfected cells. Although a powerful technique, the serial passaging method has significant limitations: low abundance viral mutants often are discarded, dilution affects cell and virus characteristics, the rate of viral evolution is prolonged, and the long-term in vivo evolutionary dynamics are not recapitulated. Maintaining appropriate cell influx and viral efflux rates in the face of viral amplification is key to recapitulating virus-host dynamics; this dynamic state is required to determine the instantaneous and steady state in virus stocks and host cell infection status (e.g., infected, uninfected, dying), which in turn is used to monitor virus mutation. One of the central challenges to overcoming these limitations is to design filters or other methods to controllably and quantitatively remove desired cells and virions.

DARPA seeks to promote the design and development of new bioreactor technology to support long-term evolutionary studies for chronic infectious or non-infectious diseases. The reactor must have continuous operation and support controllable rates on influx of fresh cells and nutrient media and the separation and removal of viral particles and different types of cells without clogging or fouling. Removed particles and cells must be sorted by their type. The reactor must support operation for sustained periods of time (minimum of 45-90 days). The system must support controlled “sampling” of the reactor contents one or more times per day. The sample should be unbiased and support additional assays of cells and supernatant such as high-throughput sequencing, molecular imaging, single cell analysis, etc. The filtering technology for removal and sorting should be characterized and validated. Designs should leverage advances in microfluidics, continuous flow, novel filtration mechanisms, or other relevant technologies. The implementation of real-time monitoring methods (i.e. optical methods) are strongly encouraged. Bioreactor systems that effectively combine more than one phase (gas, liquid, solid) or include 2- or 3-dimensional tissue-like structures will be considered favorably.

PHASE I: Develop key requirements (including ranges of influx and efflux rates gathered from published literature) and establish performance metrics for evaluation of the bioreactor. Define the components and methods to be used for filters, sorting, and other parts of system. Investigate and define risks and risk mitigation strategies. Implement a basic prototype system or a simulated system that demonstrates operating principles and fundamental performance capabilities. Establish use cases. Required Phase I deliverables will include a final report detailing the design of the bioreactor system, requirements, fabrication process, and preliminary performance results.

PHASE II: Finalize the design of Phase I and complete implementation. Evaluate the performance of the system against requirements of rates, sorting, sampling, and constraints. Demonstrate and validate the technology in at least one of the following applications: mutation dynamics in candidate viral evolution, the co-evolution of a virus and an associated therapeutic interfering particle, viral, bacterial or cellular evolution under selection pressure from antiviral drugs, immune agents, antibiotics, or anti-cancer drugs. Demonstrate continuous operation for 45-90 days with one sampling every week. Through appropriate statistical analysis of the samples, demonstrate the similarity of bioreactor dynamics to human-like conditions. Phase II deliverables will include final bioreactor design and working prototype and a final report detailing system performance for the selected application.

PHASE III DUAL USE APPLICATIONS: The end goal of this effort is to provide the community with a new type of continuous bioreactor to recapitulate human-like conditions for the study of long-term evolutionary dynamics of fast mutating pathogens, diseases and emerging pandemics of interest to DOD. The new platform technologies developed under this SBIR are expected to support investigation and design of evolving therapies such as therapeutic interfering particles. This bioreactor will also be useful to identify pathogen mutations that can escape therapies, understand the evolution of cancer cells, and dynamically track effects of therapy.

REFERENCES:
1. DARPA INTERCEPT Program. http://www.darpa.mil/news-events/2016-04-07a

2. Nowak MA, RM May (2000). Virus Dynamics. Oxford University Press. ISBN: 9780198504177

KEYWORDS: Bioreactor, evolutionary dynamics, continuous flow, filters, mutations, viral escape, long term assay

SB171-004 TITLE: Applying Novel Materials and Fabrication Techniques to Thermionic Energy Conversion

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Electronics, Materials/Processes

OBJECTIVE: Develop efficient, power-dense thermionic materials and device structures that leverage recent advances in novel device design, novel cathode and anode materials, and recent advances in semiconductor physics. Apply these advances to thermionic converters, improving their performance in terms of power densities (>10 W/cm2), conversion efficiencies (>25%), and lifetimes (>5 years).

DESCRIPTION: There is a critical DoD need to develop efficient, power-dense energy conversion materials and device structures, particularly, thermionic converters, whose thermal-to-electricity conversion efficiency is greater than competing mechanical engines. An example of thermionic energy conversion relates to the electron tube where electrons are “boiled off” a hot cathode into a vacuum and collected by the anode, resulting in electrical current. The properties of the thermionic materials used to make the cathode and anode and the internal structure of the converter limit the energy conversion efficiency and power density of the conversion process. While the field of thermionics has been around for decades, recent new materials, device designs and semiconductor fabrication techniques offer the opportunity to improve these converters, transforming long-established capabilities of thermionics in terms of the power densities, the conversion efficiencies and the lifetimes for converting heat to electricity.

PHASE I: Use novel thermionic materials and structures to design an energy converter with no moving parts whose power is scalable from watts to kilowatts. Determine key requirements and establish performance metrics for evaluation. Define thermionic materials properties and converter architectures that satisfy the fabrication process requirements. Investigate and define risks and risk mitigation strategies. Implement a basic prototype system that demonstrates operating principles and fundamental performance capabilities.

Required Phase I deliverables will include a final report detailing the design of the converter system, requirements, fabrication process, and results of the investigation into candidate materials and converter designs.

PHASE II: Finalize the design of Phase I and complete fabrication of a packaged thermionics energy converter. Evaluate the performance of the standalone system against process requirements and manufacturing and reliability constraints. Integrate materials with specific converter design defined in Phase I. Implement the fabrication process established in Phase I and demonstrate operating performance. Include risks and risk mitigation strategies to the design. Establish use cases and trade-offs for each use case. Validate design with performance testing to pre-defined performance metrics. Evaluate quality and robustness of thermionic materials. Evaluate improvements over state-of-the-art solutions.

Required Phase II deliverables will include a final report and a demonstration of the thermionic converter.

PHASE III DUAL USE APPLICATIONS: The end goal of this effort is to provide the community with thermionics materials and converters whose thermal-to-electricity conversion efficiency is greater than competing mechanical engines. Such materials and converters could be applied to man-portable systems, unmanned autonomous aerial systems, unattended ground sensors, and other systems where heat sources are readily available.

REFERENCES:

1. Becker, R. A. “Thermionic space power systems review.” J. Spacecr. Rockets 4, 847–851 (1967).

2. Rasor, N. S. “Thermionic Energy Conversion: Reflections and Projections.” 1989 Thermionic Energy Conversion Specialist Conference 11–34 (1989).

3. Khoshaman, A. H. et al., "Thermionics, Thermoelectrics, and Nanotechnology", IEEE Nanotechnology Magazine, June (2014).

4. Lee, J. H et al.., "Optimal emitter-collector gap for thermionic energy converters", Appl. Phys. Lett. 100, 173904 (2012).

5. Tavkhelidze, A. N., "Nanostructured electrodes for thermionic and thermotunnel devices", J. Appl. Phys. 108, 044313 (2010).

KEYWORDS: thermionic energy conversion, work function, vacuum electronics, anode, cathode

SB171-005 TITLE: Discovery

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop transformative knowledge navigation and document discovery software with the ability to analyze complex, multi-faceted data sets and provide the user with an intuitive interface that shows patterns and connections within the data regardless of data size or file type.

DESCRIPTION: There is a critical DoD need for new software tools that can rapidly ingest and index large data sets from archived data to provide users with methods to quickly survey and harvest pertinent information. The increasing number and size of data archives has stockpiled vast quantities of information. While the extent of archiving is viewed positive, the retrieval tools enabling rapid survey and use of the archived information have not kept pace. This data explosion opens new opportunities to extract more value from data collected by the military, academia and industry. According to research by MGI and McKinsey’s Business Technology Office, big data analysis is becoming the key basis of competition due to the increasing volume and detail of information captured by enterprises, multimedia, social media and the internet. In the commercial sector, big data can be transformative through the collection of product performance, consumer and market trend information. The ability to cultivate, analyze and display this information as meaningful output will enable organizations to make decisions regarding future investment areas.

The endeavor of making archives useful, is still underdeveloped. Search engines are one of the major strategies to cull through archived data, but only yield lists of information. Search engines do not enable the user to rapidly understand the topics embedded within the archive nor make connections between topics. Some content management tools that can search for keywords and return a list of matching files are available, but often require the user to know precisely what they are seeking. These tools fail to enable the user to explore the data archive in an organized approach. These aforementioned liabilities are particularly acute for archival systems designed to meet security requirements.

The tools that have been developed to parse and search through large datasets have not been able to incorporate growing datasets and provide applicable, useful information using visualization techniques that achieve the desired level of interactivity. A software tool that can adapt to datasets of different volumes and compositions, provide the user with the desired output and implement visualization techniques that make the system accessible is needed to deal with the rapid increase in archived data. Tools that can analyze and produce output that displays patterns, connections and actionable information for the user will be increasingly useful. The proposed system would create a collaborative platform that is not only content-rich, intuitive, and useful, but also widely applicable and customizable. The platform will create a process that can rapidly analyze structured and unstructured datasets to query, identify and visualize hidden values.

PHASE I: Analyze existing archival systems and visualization techniques that can be leveraged and improved to meet the topic objective. Conduct an analysis and create a model of a data visualization application from an existing large dataset that estimates the minimum number of assets that are required to create a viable, interactive and scalable system. Phase I deliverables include application source code, preliminary performance results, and a final report.

PHASE II: Create a data visualization software application prototype with the following capabilities: 1) can be implemented at different levels of secure environments; 2) easily ingest datasets ranging from 10,000-10,000,000 documents of varied file types; 3) index the datasets with the potential for daily, weekly or monthly updates; 4) and an innovative indexing feature adaptable to non-structured and structured datasets. The user interface for the application must meet the following requirements: 1) intuitive to navigate with no training; 2) display the data in organized categories; 3) enable users to modify the number and type of categories; 4) highlight connections between categories; and 5) display trends in the data.

Conduct market analysis of two potential areas of insertion, which includes a description of how the targeted users impacted the design and functionality of the system. Phase II deliverables will include a product that is ready for beta release for market testing, a preliminary commercialization plan, and final report.

PHASE III DUAL USE APPLICATIONS: At the conclusion of the SBIR effort, potential military partners such as the Office of Naval Research and the Army Research Office, should be contacted for interest in adopting the innovative software platform to enable increased access to pertinent information embedded in archived data. Other military organizations such as US Army Medical Research and Materiel Command (USAMRMC) could also use the technology to rapidly index their large datasets and provide a user-interface that enables the user to extract more information than the current indexing tools.

Commerical applications such as large businesses that are collecting purchasing information could use this technology to parse through their large quantities of data and display consumer information in a more meaningful and useful way.

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KEYWORDS: Data visualization, knowledge management, data archival software, information design, knowledge navigation, document search, design of data

SB171-006 TITLE: Code Interposition Framework for Mobile Cyber Applications

PROPOSALS ACCEPTED: Phase I ONLY.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Design and implement a framework for code interposition on mobile application code based on known functional code blocks and Application Programming Interfaces (APIs).

DESCRIPTION: There is a critical DoD need to develop a method for identifying, intercepting, and interposing known functional code blocks and libraries in mobile applications without altering the functionality and data flows of the targeted application. Mobile devices and their applications are increasingly relied upon by DoD. The security controls available for the most popular platforms do not always align with DoD requirements and policies. Rather than develop a new proprietary mobile platform, it is desirable to leverage existing platforms to the maximum extent possible and to add the necessary controls by controlling the application distribution channels.

The goal is to produce a framework that can identify, intercept, inspect, and instrument known libraries and code blocks, including code that describes user actions, environmental sensing, and system events among others. The ability to identify code blocks and instrument them based on the application package should be transparent and should not interfere with the application functionality and data consumed or produced by the application itself. Modified applications would then be delivered to managed handsets through appropriate means, e.g., a DoD-only application store. All popular mobile platforms are of interest, with a particular emphasis on iOS and Android. Proposers may focus on a single platform, and need not consider the application distribution channel as part of their proposed effort. The code interposition framework should be able to instrument all paths through the identified set of code blocks within the targeted application using static analysis of the binary and managed code of the mobile application. At later phases of the project, dynamic analysis could be used to ensure that all potential paths have been instrumented and to intercept known code blocks if they are introduced during runtime. One of the challenges is that the application may be presented as a packaged binary which may be heavily obfuscated or may employ anti-debugging and integrity checking techniques; any proposed solution must address such challenges, and proposers must clearly articulate their approach to doing so. The framework should also be able to handle unobfuscated complex applications using interfaces to native code. In case of inability to analyze or instrument the application binary, the framework may be able to use less optimal instrumentation points by instrumenting code entry and exit points to the code that is being obfuscated. It is envisioned that the system will use both dynamic analysis and static analysis so that it is not bound by the limitations that are inherent in using only one approach. The system should provide some guarantee of adequate code coverage of the applications that it processes without creating significant overhead when processing a set of applications. Chandler et al. [1] and Binder et al. [2] have proposed different techniques that can achieve bytecode instrumentation, by inserting additional instructions in Java bytecode using multiple techniques. Dynamic analysis has the limitation of ensuring adequate code coverage and the analyzed application may display different behavior if it detects being executed in a controlled environment. DARPA needs a framework to utilize both static analysis and dynamic analysis to help overcome the shortcomings of each approach and augment each other for a more comprehensive analysis.

PHASE I: Conduct a feasibility study to determine innovative cyber techniques and mechanisms that can be used within a methodology to identify, intercept, and interpose known functional code blocks and libraries in mobile applications without altering the functionality and data flows of the target application. Design, prototype, and evaluate the resulting concept framework capable of using code interposition on mobile application binary and managed code based on known functional code blocks and Application Programming Interfaces (APIs). The initial prototype may simply instrument code entry and exit points to the obfuscated code. As part of Phase I, a test case with success criteria for the mobile application should be defined. Phase I deliverables will include a final report that details initial prototype design and concept framework, and preliminary results of the test case.

PHASE II: Fully develop the Phase I concept framework, and include both static and dynamic analysis to ensure that all potential paths have been instrumented and to intercept known code blocks if they are introduced during run-time. The system should provide some guarantee of adequate code coverage while keeping runtime overhead to a minimum. The initial prototype capability developed will support multiple techniques for testing the efficacy of the resulting code interposition framework. The resulting prototype will be demonstrated in accordance with the demonstration success criteria developed in Phase I. Phase II deliverables will include a working prototype and final report that details demonstration results.

PHASE III DUAL USE APPLICATIONS: This dual-use technology applies to both military and commercial environments affected by cyber adversaries. Commercial benefits include increased cyber warfare protection of infiltration of a company's perimeter/network through mobile devices, and thus, increased protection of critical infrastructure environments (e.g., health, electrical, transportation, etc.). In addition, the developed framework may be commercialized for use with a mobile device that interfaces with a commercial enterprise level system that can be used to detect heavily obfuscated or anti-debugging and integrity checking techniques employed by a cyber intruder.

The DoD and the commercial world have similar challenges with respect to maintaining the integrity of their cyber computing and communications infrastructure. The DoD is concerned both about in-house and third-party (commercial) mobile devices in existence today and being able to effectively detect the cyber intruder within operational systems that support the warfighter. The resulting code interposition framework for mobile applications that can identify, intercept, inspect, and instrument known libraries and code blocks, including code that describes user actions, environmental, and system events, with a DoD-only application store is directly transitionable to the DoD for use by the services (e.g., Space and Naval Warfare Systems Center (SSC), Air Force Research Laboratory (AFRL)).

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KEYWORDS: Cyber defense; Mobile application binary code: Functional code blocks; Instrumentation; Code interposition; Dynamic analysis; and Static analysis.

SB171-007 TITLE: Modeling Human Dimensions of the Cyber Ecosystem

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Human Systems, Information Systems

OBJECTIVE: Represent and analyze human behaviors within a cyber ecosystem (consisting of software, hardware, and human users) to support assessment of overall ecosystem security.

DESCRIPTION: There is a critical DoD need to develop computational models and tools to represent and analyze human capabilities and behaviors (e.g., attention management, information processing, error, workload, cognitive biases, social learning) that affect the security of a cyber ecosystem – that is, the overall sociotechnical system consisting of humans, software, hardware and their interrelationships. Computational models and tools for representing and analyzing the human dimensions of security should be used as part of a broader verification process to assess a cyber ecosystem's overall security. Assessments of cyber ecosystem security that integrate an understanding of human capabilities and behaviors will result in more accurate decisions regarding whether a system is adequate for specific applications, and will help guide remediation efforts such as the development of security policy modifications, personnel training plans, and specific technological countermeasures.

Risk assessment for conventional cyber security focuses on formally proving that software has no vulnerabilities (e.g., buffer overflows or cross-site scripting) and/or systematically testing with less formal verification processes (e.g., assessing architectural design and known software vulnerabilities through scans, performing analysis of static/dynamic code). Other cyber security efforts focus on creating computing hardware that resists various forms of exploitation. However, even when software and hardware vulnerabilities are eliminated, the interaction of humans with that software and hardware can lead to new and unexpected vulnerabilities. The range of relevant forms of human interaction with a system is broad, spanning not only the end-users of systems, but also system and network administrators, policy makers, system designers, malicious actors external or internal to the organization, as well as the various types of behaviors exhibited by each. Securing an overall cyber ecosystem must therefore address the potential for vulnerabilities that could be introduced from across all forms of human interaction with the system. If the human capabilities and behaviors that exist within a cyber ecosystem could be accurately represented in computational form, the security of any such system could be rapidly assessed during and after development.

This effort will develop a modeling framework that supports integration of diverse data sources from the cyber domain and inferred human capabilities and properties (e.g., psycho-social factors, patterns of life, cognitive and perceptual factors) to enable the creation of models of human behavior within the cyber ecosystem, as well as the rigorous validation of such models. The models should reflect a wide range of vulnerabilities, ranging from the unintentional and careless to dedicated adversarial behaviors. The effort must include modeling human behavior beyond the user interface—the goal is not to merely confirm the functionality of the user interface, but rather the inherent complexity found when multiple humans are interacting in a variety of ways with a system and each other.

This effort will marry research in modeling human behavior with formal security analysis methods to identify system vulnerabilities that are "reachable" given varying levels of human intentional and unintentional behavior. One result of this work will be an assessment of the likely risk of activating the human-associated vulnerability for a system and its operational policies. This approach will provide additional and immediate benefits through the assignment of monitoring resources, training, improvements to cyber technologies, and/or revisions in security policies to improve resilience against the highest value threats.

PHASE I: Prototype a framework for assessing overall security of a cyber ecosystem by combining models of human behavior with models of cyber infrastructure (software, security systems, security policy). Design computational methods and models to represent and analyze cyber-relevant human behaviors. Demonstrate plausible approaches to acquire those computational models from existing and/or new data sources. Develop a plan and metrics for validating models against real-world data and/or experiments, and assessing the utility of the models for cyber ecosystem security evaluation. Phase I deliverables will include a final report including a description of validation plans for Phase II and a demonstration of the prototype human behavior model(s).

PHASE II: Implement the framework for assessing overall security of a cyber ecosystem using models of human behavior and cyber infrastructure. Develop a scalable implementation of computational models of human behavior, and enhance with the results of data collection/experimentation. Perform ongoing, frequent validation and utility assessment of models and model components against real-world data as per the Phase I plan. Phase II deliverables will include software and technical reports, and a final report with recommendations for transitioning the models to operational systems.

PHASE III DUAL USE APPLICATIONS: Potential U.S. Government stakeholders and transition partners include DoD acquisition programmatic test and evaluation labs, United States Cyber Command and their Service components. However, cyber security is far from a military-only concern. Commercial organizations generally face a more difficult security risk situation due to lack of control and influence over both their members and the hardware and software systems they use. Therefore, they have a greater need for organization-wide security posture assessment tools—and the technologies developed in this effort will be equally applicable to military and commercial analyses.

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KEYWORDS: cybersecurity, vulnerabilities, human behavior modeling, software verification, model validation, trust

SB171-008 TITLE: Harnessing Open-Source Signals for Detection of Systematic Intervention in Online Discourse

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Human Systems, Information Systems

OBJECTIVE: Develop a generalizable approach and enabling software for detecting and analyzing systematic interventions in online discourse.

DESCRIPTION: There is a critical national security need to understand the priorities of other governments, a task that is particularly difficult when dealing with opaque, authoritarian systems. The U.S. has important relationships with countries that engage in information control practices (e.g., restricting freedom of the press), which make discerning the policy goals of leadership difficult. Policy discussions are not held in public forums, official statements tend to be broad or vague, and local media is frequently subject to strict publication limitations. However, regimes that exert great effort in managing the flow of information also tend to engage in similar and complementary information control practices online. The Internet has provided many platforms to share news and ideas in an unregulated manner, even in countries where the information environment is closely regulated. Government efforts to control the flow of information online (via tactics such as censorship, sock-puppeting, and/or astroturfing) leave an imprint that can be measured and interpreted as a representation of which topics or people are considered important to those in power.

Comprehensively tracking systematic efforts to control information is a significant technological challenge, particularly in the diverse, voluminous, shifting, and multilingual online environment. To accurately track online interventions, the action of foreign governments must be studied at high speeds and on large scales with multiple algorithms designed to consistently detect online intervention and correlate trends, given that "ground truth" - by design - is hidden. To make sense of the signal at scale, these algorithms will require automated text analytic techniques tailored to the target language, baselining and trend detection methodologies, topic modeling, and regional or sub-national analysis. This effort seeks to develop an ensemble of generalizable approaches and associated algorithms for detection of online interventions in discourse – and is focused on text (although extensions that address audio, imagery, and/or video are not excluded). Generalizing approaches is challenging, given the need to accommodate: (1) different and dynamic languages and media consumption patterns; (2) ongoing changes in a foreign government's topical interests and tactics; and (3) the wide variety of means by which information flows online.

This effort will include the identification and/or extraction of publicly available information from foreign online media and social networking sites that contains one or more signals created by the online intervention of foreign governments. Identification and extraction efforts are difficult for a variety of reasons, including the multitude of forums to monitor, the need to identify posts in near-real time to ensure they are collected before they are altered or removed, and the need to systematically separate relevant content from irrelevant content that might be altered or removed (e.g., spam). Successful implementation will depend on two aspects working in harmony:
(1) comprehensive data identification and/or extraction infrastructure adaptable to different regions; and
(2) robust and regionally sensitive post-collection analysis.

The effort will ensure compliance with all relevant policies and regulations on the protection of human subjects in research.

PHASE I: Develop a system design concept to identify, extract, and analyze one type of online intervention in a single country, including the infrastructure for obtaining and analyzing at least two sources of anonymized, foreign social media data. Acquire data. Demonstrate approach to analyzing online intervention, including demonstration of all system components and analytic products. Phase I deliverables will include a final report that describes measured instances of online content manipulation and a replicable research approach, as well as the design of a software architecture.

PHASE II: Apply the Phase I proof of concept to another country to test the prototype's ability to observe and quantify online intervention in a locale-agnostic manner. After multi-region data acquisition, apply regionally sensitive detection algorithms for each national data set and refine to produce accurate results across data sets. Evaluate software's ability to correlate online intervention with real-world events and policy-relevant subjects. Test ability to develop sub-national (regional) tuning. Phase II deliverables will include software and technical reports, including a final report containing recommendations for transitioning the models to operational systems.

PHASE III DUAL USE APPLICATIONS: The resulting technology has potential to commercialize into the financial industry, particularly investors who pursue international partnerships and need new sources of information on in-country events and government posture. The DoD and other federal agencies have considerable interest in improving awareness of foreign government policy priorities, particularly for opaque regimes who practice tight information control. Therefore, the resulting technology has potential to transition to agencies whose mission is to track which policy areas are the focus of foreign government information control efforts, as well as to monitor changes or trends in those efforts.

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KEYWORDS: online discourse, text analytics, social media, social networking, policy-making

SB171-009 TITLE: Force Protection in the Online Information Environment

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Human Systems, Information Systems

OBJECTIVE: Develop automated software tools that use publicly available information (PAI) to detect intent, within foreign populations, to harm U.S. forces stationed overseas, while ensuring privacy and appropriately addressing personally identifiable information that may be found in PAI.

DESCRIPTION: The DoD is increasingly relying on publicly available information (PAI), including some forms of social media, to develop situational awareness and identify potential threats to overseas forces. Capabilities have been demonstrated to monitor PAI and analyze sentiment, attitudes about specific topics, as well as group properties such as organizational structure, cohesion, and extra-group affiliations. Such attributes can and have been used to monitor the shifting attitudes of groups through their exhibited behavior in social networking environments and other online forums in which such information is openly published. However, a key remaining challenge is determining if exhibited behavior in PAI that appears to have some characteristics of threat behavior actually represents a real threat, or merely some other purpose (venting, appearing agreeable to an affiliated group, etc.). That is, it is a challenge to assess not only if expressed beliefs or attitudes are sincere, but also whether those beliefs or attitudes are a likely source of intentionality and action. This challenge is made more difficult by the potential for a group to act covertly or to practice deception.

This effort will pursue the ability to accurately detect and predict a group's intention to act within expressive behavior in PAI. This effort will consider intention as a phenomenon distinct from attitude or belief expressions themselves. Preference will be given to approaches that hold promise of resilience across differing sources of PAI (e.g., different social networking environments, online news), languages, cultures, and topics. In addition, any successful effort will include a comprehensive plan for ensuring privacy , appropriately addressing personally identifiable information that may be found in PAI, and ensuring that only PAI from foreign populations is considered.

PHASE I: Develop an approach for detecting beliefs, attitudes, or other characteristics of a foreign group and their network that predicts intention to act as a function of communications seen in PAI. Document these characteristics with a clear rationale for why they are likely to help anticipate threatening actions taken against U.S. forces overseas, and for which behavioral and environmental contexts they are likely to be successful. Demonstrate the approach with real or representative data and develop a plan for rigorous validation of the approach in Phase II using multiple data sets and/or non-historical data. Demonstrate that the approach will ensure privacy, address personally identifiable information that may be found in PAI, and ensure only PAI from foreign populations is considered. Phase I deliverables will include a demonstration of the approach for at least one use case, and a final report including a description of validation plans for Phase II.

PHASE II: Design and implement an intent-to-act detector using the approach demonstrated under Phase I. Continuously evaluate and validate the detector on multiple data sets, as per the Phase I plan. Extend the detector across different forms of PAI, cultures, languages, and intended real-world behaviors. Phase II deliverables will include software and technical reports, and a final report with recommendations for transitioning results to operational systems.

PHASE III DUAL USE APPLICATIONS: Potential DoD applications for this technology include protection of U.S. forces in the digital domain, not only to detect potential threats, but also to identify potential lapses in operational security that may occur in the online environment. Potential commercial applications for this technology include: brand marketing, advertising, competitor analysis, and organizational health assessment.

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KEYWORDS: Force protection, social media analysis, intention, beliefs and attitudes, cross-culture study

SB171-010 TITLE: Ultra-Compact Power Conditioning System for High Power RF Transmitters

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Electronics, Weapons

OBJECTIVE: Design and demonstrate an innovative high voltage power supply/modulator utilizing novel components and/or topologies to significantly reduce the size and weight of high power RF transmitters based on vacuum electronics.

DESCRIPTION: There is a critical DoD need to reduce the volume and weight of high power RF transmitter systems. The power supply is a key component of the transmitter. This solicitation seeks to develop the enabling technologies to significantly reduce the footprint and weight of power supplies for transmitters based on vacuum electronic amplifiers and to demonstrate innovative power supply architectures in a relevant application. Vacuum electronic (VE) amplifiers such as traveling-wave tubes (TWTs) often are the technology of choice for transmitter applications requiring operation with high power-bandwidth product performance at microwave and millimeter-wave frequencies. A high voltage power supply/modulator (HVPS/Mod) provides the conditioned voltages and currents to the TWT and is a critical component of the transmitter system. Typically, the HVPS/Mod consists of a cathode supply, heater power supply for the thermionic electron gun, a modulating anode or grid supply to gate the electron beam on and off, and supplies to bias multiple depressed collector stages in a topology that enables true energy recovery of the spent electron beam for overall system efficiency enhancement.

Increasingly, constraints on platform size and available prime power are placing challenges on the volume, weight, and efficiency of the HVPS/Mod. This topic seeks the development and demonstration of new HVPS/Mod topologies and components to significantly reduce the HVPS/Mod system SWaP (size, weight, and power requirements) and to increase the power density up to 1 Watt/cm^3 (>3x the current state-of-the-art). Innovative architectures that can exploit higher switching speeds with low losses are desirable as are the development and incorporation of new materials and components such as (but not limited to) high speed, high voltage solid-state switches and rectifiers; high frequency, high saturation field, low-loss magnetics; compact, high voltage capacitors that can tolerate high ripple currents ; compact high voltage connectors; improved high voltage dielectrics; and improved high voltage packaging and encapsulation.

The overall topic goal is to demonstrate innovative power supply architectures for applications in RF transmitter systems and to develop the enabling technologies to significantly reduce the volume and weight. To provide a focus for the development, the specific performance goals for this topic are a cathode voltage and current of 20 kV and 1.5 A, respectively; 100% duty operation; a maximum modulating anode voltage swing of -3 kV (beam off) to +1.5 kV (beam on) with respect to the cathode voltage; cathode heater DC power of 12 V and 5 A with respect to cathode voltage; and up to four stages of depressed collectors for energy recovery with a goal of reducing the prime power requirement to approximately one third of the beam power.

PHASE I: Conceptualize and design an innovative HVPS/Mod architecture with a power density of up to 1 W/cm^3 and capable of meeting program performance goals. These goals include a cathode voltage and current of 20 kV and 1.5 A, respectively; 100% duty operation; a maximum modulating anode voltage swing of -3 kV (beam off) to +1.5 kV (beam on) with respect to the cathode voltage; cathode heater DC power of 12 V and 5 A with respect to cathode voltage; and up to four stages of depressed collectors for energy recovery with a goal of reducing the prime power requirement to approximately one third of the beam power. The overall HVPS/Mod power-added efficiency should exceed 85%. Key components and enabling technologies will be investigated, assessed, and identified for incorporation in the design.

Phase I deliverables include the HVPS/Mod electrical design and preliminary mechanical design, the identification of innovative component technologies, and a plan for their development and implementation.

PHASE II: Develop, fabricate, and demonstrate a prototype HVPS/Mod based on the Phase I work. Finalize electrical and mechanical engineering designs. As necessary, developmental components and sub-assemblies will be tested and validated. A series of laboratory tests will demonstrate that the prototype hardware meets the power density and electrical performance goals set out in Phase I.

Phase II deliverables include all HVPS/Mod hardware and a report documenting test results and innovative component development.

PHASE III DUAL USE APPLICATIONS: Vacuum electronics is a critical defense technology. At present, over 80% of the microwave and millimeter-wave transmitters in fielded DoD systems are based on vacuum electronic amplifiers and oscillators. Compact high voltage power supply/modulators are a key component for all of these systems and are a critical enabling technology for future applications on land, air, sea, and space-based platforms. These applications include jam resistant high data rate digital communication systems capable of operation in adverse environmental conditions, high resolution radar with extended range, and high power, broad bandwidth transmitters for electronic attack. The HVPS/Mod architectures and advances in innovative component technologies resulting from the Phase I and II research will enable new systems with significantly lower SWaP compared with the current state-of-the-art.

Commercial applications would also benefit from reductions in HVPS/Mod SWaP. For example, the reduced volume and weight would enable higher power transmitters to be mounted directly on ground-based antenna feeds resulting in lower system losses and increased range of operation. Furthermore, the technology could be used in satellite communications. Over 90% of the geosynchronous communications satellites use TWT amplifiers. Reductions in the size and weight of the power supply/modulators would have immediate benefits. For example, reduced SWaP would allow the inclusion of more amplifiers on a given satellite to increase channel capacity and/or improve reliability, or reduce the overall size and weight of the satellite to minimize launch costs.

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6. W. Shen, F. Wang, D. Boroyevich, and C. W. Tipton IV, “High-density nanocrystalline core transformer for high-power high-frequency resonant converter,” IEEE Trans. on Industry Applications 44(1), Jan/Feb 2008.

7. Additional Topic Briefing, November 30, 2016 (uploaded in SITIS on 11/30/16).

KEYWORDS: vacuum tube electronics, millimeter wave, microwave, amplifier, transmitter, oscillator, power supply, power modulator, traveling wave tube, power electronics

SB171-011 TITLE: Recommender Systems for Streaming Data Environments

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop innovative approaches that enable recommender systems to take advantage of domains where the set of available features changes over time.

DESCRIPTION: There is a critical DoD need to develop “recommender” systems that process data based on streaming rather than static feature sets to more intelligently automate big data analysis and cue pertinent information for analysts and planners. Recommender systems have been a staple of many recent successful businesses including Netflix’s movie suggestions and Amazon’s product recommendations. They are also rapidly emerging in many other fields such as personal health recommendation and can similarly be expected to play a larger role in intelligence analysis and command and control functions of Department of Defense (DoD). For example, such a system could help an analyst cue-in on critical aspects of an image, or serve as a virtual decision-aide in the construction of courses of action during mission planning.

These systems typically work by identifying trends or patterns in data to associate past behavior with future tendencies. For example, based on a given user’s past movie history rankings and what their friends rated highly, a recommender system can generate a short list of movie suggestions that the user will most likely want to watch next. A critical piece of such functionality depends on the features that describe the data; from the above example they would include a user’s movie rating history, network of friends, movie genre, etc. In the past, recommender system designers would hand tune this set of features and it would remain static for months or years, but this approach ignores many other potentially beneficial features that could be found from available data.

Consider the problem of recommending articles posted on social media websites. Typical features would consist of a predefined set of words and topics; however, the language of social media changes frequently. New slang words and event-driven topics may greatly alter the meaning of articles; recommender systems built on fixed feature sets without these words may be unable to keep up with current trends and fail to meet user expectations. This is an example of the need to incorporate streaming features – new words in this example – to improve recommender system performance.

PHASE I: Identify one or more relevant data sources and recommendation targets applicable to those sources. Design an algorithmic approach to enable a recommender system to take advantage of streaming features produced by the identified data source(s). Phase I deliverables must include a final report documenting the data sources considered and the algorithmic approach to be pursued in Phase II.

PHASE II: Implement and demonstrate the algorithm produced in Phase I results in a successful recommender system for the selected problem area. Evaluate the proposed recommender system against recommender systems that use only static (non-streaming) feature subsets to demonstrate potential gains to be achieved by using streaming features. Phase II deliverables must include a prototype software implementation of the algorithm as well as a final report that documents the software, system design, and evaluation results.

PHASE III DUAL USE APPLICATIONS: This effort has the potential to enable several resilient recommender systems to be developed as virtual decision-aides for defense systems (tipping and queuing for intelligence analysts, course of action planning in command and control processes, etc.); and may have a broad impact in the commercial sector (improved product recommendations, tailored newsfeeds, personalized health plans, etc.).

REFERENCES:
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2. D. Doychev, A. Lawlor, R. Rafter, and B. Smyth. "An Analysis of Recommender Algorithms for Online News". In the proceedings of the Conference and Labs of the Evaluation Forum: Information Access Evaluation Meets Multilinguality, Multimodality and Interaction (CLEF) 2014.

3. F. Hopfgartner. "Real-Time Recommendation of Streamed Data". Tutorial presented at the ACM International Recommender Systems Conference (RecSys) 2015.

4. J. Li, X. Hu, J. Tang, H. Liu. "Unsupervised Streaming Feature Selection in Social Media". In the proceedings of the International Conference on Information and Knowledge Management (CIKM) 2015.

5. X. Wu, K. Yu, W. Ding, H. Wang, and X. Zhu. "Online Feature Selection with Streaming Features". In the proceedings of the IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI), vol. 35, no. 5, 2013.

KEYWORDS: recommender systems, online feature learning, streaming feature selection, machine learning, artificial intelligence

SB171-012 TITLE: Non-linear Adaptive Optics

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Sensors, 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 5.4.c.(8) of the Announcement.

OBJECTIVE: Develop adaptive optics (AO) for beam control of high energy ultra-short pulse lasers (USPLs) propagating through non-linear media.

DESCRIPTION: There is a critical DoD need to develop and demonstrate an adaptive optical beam control system optimized for use with high energy, ultra-short pulse lasers and propagation in non-linear media such as the atmosphere. USPL pulses propagating through a non-linear medium such at the atmosphere undergo self-focusing due to the non-linear interaction between the high-peak-power optical field and the propagation medium[1], and may undergo other non-linear optical interactions, for example (but not limited to) Raman or Brillouin scattering. DARPA is interested in developing adaptive optics which enable precise beam control of non-linear optical beam propagation in uncontrolled turbulent and non-linear media, in particular in the atmosphere. The propagation of high-peak power short pulses is influenced by the spatial, spectral and temporal profile of the pulse.[2] Therefore, “adaptive optics” in this announcement is extended to include or interface with methods of dynamic manipulation of the spectral and temporal profile of the laser pulse as a secondary or augmented capability. The adaptive optical system to be designed shall include a method of spatial wavefront correction (e.g. deformable mirror (DM)), a spatial wavefront sensor (WFS), a diagnostic method of closed-loop feedback (such as a guide beacon), and a closed-loop control system with control software and user interface. The system shall be designed to accommodate short pulse lasers with pulse energies up to 1J, pulse lengths varying from 100fs to 100ps, and peak power levels of 10-1000 GW. The system should be compatible with operation in the near-IR (~0.8-1.1μm), short-wave infrared (1.3-2.5μm), and/or the mid-wave infrared (3.5-4.2μm). The wavefront correction components should be capable of dynamically correcting moderate to high spatial frequency scales such as those expected for optical propagation through a turbulent atmosphere. DARPA desires near-diffraction-limited correction of wavefront errors with spatial frequency less than or equal to 6/(clear aperture), in a clear aperture of 2-8 cm, at rates >100Hz, with a peak-to-valley dynamic range of 6 microns excluding full-aperture tilt. This is approximately equivalent to an ability to compensate for up to the sixth order of aberrations in Zernike polynomials. A means of diagnostic feedback to the closed-loop wavefront control is an important part of the system. It can be assumed for the purpose of this effort that the transmitted USPL pulse will be brought to a self-focus at a predetermined distance. The high-peak-power USPL pulse will experience distortions of non-linear effects during propagation that would not happen to a lower power beam propagating through the same medium when the USPL pulse is not present. Therefore, there is special interest in AO methods which utilize measurements of the USPL focus viewed from the launch aperture location as a diagnostic source.

This is a significant departure from traditional AO systems which rely on direct wavefront sensing and reciprocal symmetry of the propagation path. However, systems which utilize independent wavefront measurements of the linear propagation paths, or other methods, are acceptable if they can obtain some degree of sensing and correction of the non-linear propagation path[4]. Novel control solutions such as “sensorless” methods[3] are of interest to address this issue. In addition, the propagation of a USPL pulse in a non-linear medium can be altered by changing the spectral/temporal profile of the pulse. In atmospheric propagation, for example, analog modulation of the spectral or temporal profile is desired with resolution of 1/10 (or less) of the spectral or temporal width. Consequently, AO closed-loop methods that can interface with spectral/temporal pulse control systems and can utilize such spectral/temporal controls in open- or closed-loop coordination with spatial wavefront control are of particular interest.

PHASE I: Develop a detailed description of the adaptive optical system, including wavefront measurement methods and sensors, wavefront correction methods and materials, and control system methods and algorithms. This description should include a performance estimation of residual wavefront error, closed-loop bandwidth, and a preliminary evaluation of the expected size, weight, and power consumption of a complete prototype system implementation. The Phase I design description should address the ability of the proposed approach to accommodate ultrashort pulsed power levels of up to 100 GW and up to 1J of pulse energy. In addition, the Phase 1 effort should address the control-system approach and provide an analytic validation that the proposed approach can converge to a desired solution in the presence of non-linear optical effects. Phase I deliverables will include a Kickoff Meeting briefing, monthly technical and financial status reports, a Final Review briefing and a narrative Final Report.

PHASE II: Demonstrate the Phase I concept via brassboard experiments. In Phase II, a Phase I concept will be reduced to practice at full scale, and its performance validated in a laboratory setting. The experiments conducted should result in empirical and/or analytic knowledge that may be used to further optimize and/or upgrade the system to a prototype AO system. The laboratory brassboard must provide characterization data that demonstrate by analysis that the performance objectives can be met. It is expected that the brassboard system with minor modifications could be subsequently utilized in a field experiment that would directly meet the performance objectives in the atmosphere. Phase II deliverables will include a Kickoff Meeting briefing, monthly technical and financial status reports, a System Requirements Review briefing and report, an Experiment Plan, a Final Review briefing and a narrative Final Report.

PHASE III DUAL USE APPLICATIONS: AO systems capable of providing beam control for non-linear optical beams may find military applications in high-energy laser systems and in standoff chemical identification systems. Commercial applications may include laser material characterization, processing and manufacturing with ultra-short pulse lasers, medical imaging, and optical communication.

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2. Durand, M., et. al., “Kilometer Range Filamentation”, Opt. Express 21, 26836-26845 (2013)

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5. Additional Topic Briefing, December 7, 2016 (uploaded in SITIS 12/7/16).

KEYWORDS: adaptive optics, ultrashort pulse laser, nonlinear optics, atmospheric propagation, self-focusing, beam control, nonlinear propagation

SB171-013 TITLE: Load Bearing Thermal Protection Structure for Hypersonic Flight

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Air Platform, Materials/Processes

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 5.4.c.(8) of the Announcement.

OBJECTIVE: Develop and demonstrate lightweight, low-cost, load-bearing thermal protection structure for hypersonic flight.

DESCRIPTION: There is a critical DoD need for penetrating intelligence, surveillance, and reconnaissance (ISR) for which hypersonic cruise vehicles may be a potential solution. Hypersonic cruise vehicles require the use of high-temperature resistant materials to withstand the high thermal fluxes and integrated thermal load during flight. The focus of this SBIR is on air-breathing hypersonic cruise vehicles in the Earth’s atmosphere. In order to achieve manufacturing and maintenance cost savings as well as weight reduction, structural concepts for a load-bearing thermally protected structure are needed. Structural concepts for hybrid thermal protection systems (TPS) and hot structure components, including leading edges, aerodynamically heated remaining structure, and control surfaces are sought to improve on the state-of-art. The current state of the art in hypersonic structures faces two technical challenges: environmental durability and fabrication; additionally, weight penalty is incurred since the TPS is parasitic and not load-bearing. System mass, conformal shape, manufacturing costs and complexity of structure become important where state of the art structural concepts fall short of meeting envisioned future mission requirements.

PHASE I: Define the specific performance goals for the proposed load bearing structure based on the intended class of structural components for hypersonic vehicles. Provide detailed rationale for the concept in terms of cost and weight savings. Perform preliminary design of the structural part. Predict thermomechanical performance by low-fidelity analysis and compare performance to government provided data on existing TPS/hot structures. The Phase I final report will include a manufacturing and experimental evaluation plan to be executed under Phase II.

PHASE II: Finalize, fabricate, and validate a load-bearing thermal protection structure for a class of hypersonic aircraft parts. Quantify manufacturing cost for low-rate and intermittent-demand production. Execute the experimental plan developed under Phase I to evaluate relevant thermomechanical properties in a laboratory environment simulating critical application requirements. Work with government team to identify a target-field testing vehicle that can be used for real environment testing in Phase III. Deliverables will include a prototype structural part, manufacturing cost analysis, weight saving estimates and technical reports and recommendations for transitioning the technology to operational systems.

PHASE III DUAL USE APPLICATIONS: Commercial Application – Potential avenues of early transition include the growing group of commercial firms exploring reusable space access vehicles. This new technology would reduce their launch system weights. Similarly, but in its early stages, commercial firms are also beginning to explore the business case for both supersonic and hypersonic commercial aircraft.

DOD/Military Applications - Weight on the back end of next generation fighter aircraft needs to be reduced for the aircraft to reach the range needed in the future. Increased thermal loads from thermally isolated engines can also lead to early structural failure (O&M issues) and weight issues. This technology would directly address both of these issue areas for these aircraft. Additionally, all hypersonic aircraft would directly benefit from increased range and/or payload resulting from weight reductions.

REFERENCES:
1. S. D. Kasen, “Thermal Management at Hypersonic Leading Edges,” Ph.D. Dissertation, University of Virginia, 2013.

2. David E. Glass, “Ceramic Matrix Composite (CMC) Thermal Protection Systems (TPS) and Hot Structures for Hypersonic Vehicles,” AIAA-2008-2682

3. Villace V. & Steelant J. (2015), ‘Thermal Paradox of Hypersonic Cruisers’, 20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference, 6-9 July 2015, Glasgow, Scotland, AIAA-2015.

KEYWORDS: Hypersonic flight, hot structures, thermal protection, thermal isolation

SB171-014 TITLE: Adaptive Control and Advanced Sensing for Turbine Based Combined Cycle Vehicles

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Air Platform, 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 5.4.c.(8) of the Announcement.

OBJECTIVE: Develop an adaptive control system for high-speed propulsion systems that leverages self-learning and distributed sensors on board and integrates them into the vehicle and propulsion systems.

DESCRIPTION: There is a critical DoD need for a robust turbine-based combined cycle (TBCC) propulsion-control scheme for hypersonic aircraft. One of the major challenges when operating a TBCC engine is obtaining stable mode transition while achieving the required performance and operability over the entire flight range. During this process, a successful propulsion control and actuation system must: (1) avoid inlet and/or engine unstart [1], (2) mitigate low-/high-speed inlet/engine interactions, (3) account for backpressure and moving-structure positioning effects, and (4) deliver optimal vehicle performance. [2]

Current sensors suffer from an inability to survive the hypersonic environment and provide reliable, distributed data such as pressure, temperature, heat flux, shear, displacement, flow velocity/Mach number, etc. Current sensors do not integrate well into hypersonic vehicle structures—whether they are high-strength metal alloys or hot ceramic structures—for a variety of reasons. Proper sensor selection and integration is vital to enabling an adaptive control system that can be successful over all vehicle operating modes.

The coupling among the aerodynamics, propulsion system, structure, controls, and thermal system presents a complex modeling and control problem that must be addressed before these combined-cycle vehicles can achieve regular operation.

PHASE I: Develop a preliminary adaptive control system architecture with integrated sensor requirements for a TBCC propulsion system. Study overall key control system performance drivers and derive the anticipated system performance metrics, and expose potential limitations of current state-of-the-art sensor systems as inputs to the control system. Conduct system-level modeling and analysis and show improvements in propulsion and overall vehicle performance. Phase I deliverables will include a final report that contains initial adaptive control system design and preliminary performance results.

PHASE II: Complete development of the adaptive control system and perform ground and/or flight testing of its control/sensing solution. Focus should be on validation of the control system to achieve smooth and stable mode transitions without inlet unstart and stable operation with high performance in both the low-speed and high-speed flowpaths. Phase II deliverables will include a final report that contains the finished adaptive control system design and demonstrations results.

PHASE III DUAL USE APPLICATIONS: An innovative adaptive control system may be an enabler of future supersonic and hypersonic commercial aircraft may enable the military to develop a reusable hypersonic aircraft for intelligence, surveillance, and reconnaissance (ISR).

REFERENCES:
1. Bakos, R., Go, G., Beckel, S., Goyne, C., Di, L., Lin, Z., Calleja, J., Caspermeyer, M., Donbar, J. “Active Control of Scramjet Isolator Shock Systems.” 63rd, JANNAF Propulsion Meeting. Newport News, VA 16-19 May 2016.

2. Thomas, S.R., Walker, J.F., “Fundamental Aeronautics Program – Hypersonics Project: Overview of the TBCC Discipline.” 2009 Annual Meeting. September 29 – October 1, 2009.

3. Rock, K., Olson, D., Philpott, J. “Perspectives on Integrating Combustion Control in the Design and Development for High-Speed Airbreathing Propulsion Systems.” JANNAF 45th CS / 33rd APS / 33rd EPSS / 27th PSHS Joint Subcommittee Meeting Monterey, California December 3 - 7, 2012.

4. Thomas, S.R., “TBCC Technical Challenge Overview, Hypersonics Project.” 2012 Technical Conference, Cleveland OH, March 13-15, 2012.

KEYWORDS: Turbine based combined cycle, TBCC, adaptive control, embedded sensors

SB171-015 TITLE: Spacecraft Identification Device

PROPOSALS ACCEPTED: Phase I ONLY.

TECHNOLOGY AREA(S): Electronics, Space Platforms

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 5.4.c.(8) of the Announcement.

OBJECTIVE: Develop a radio frequency identification (RFID) or other extremely low-power device that can be integrated into spacecraft or other space objects (e.g., rocket stages) without any direct power or data connection to the host, and provides a unique identification code along with information about the position and state of health of the host platform.

DESCRIPTION: There is a critical DoD need to promote the development of means of tracking and characterization of space objects beyond the limitations of our current optical and radar-based methods. This need can be fulfilled by a collaborative RF-based tracking architecture, with a primary focus on an innovative, small, lightweight RFID or extremely low-power electronic device. Such a device should be suitable for installation and operation on spacecraft or rocket upper stages, and be capable of transmitting a unique identification code either upon RF interrogation, or in a systematic fashion consistent with its design architecture. In addition, this device should transmit position information and telemetry that provides an indication of the object's state of health (perhaps based on angular velocity or changes therein). The device should operate independently from the host object, and should not require power or data from the host. It should be small and lightweight, so as to minimize the impact on the host object's operations and other systems. The device should have an operational lifetime comparable to the on-orbit duration of the host object, which may vary from months to decades depending on the host platform. A systematic means of interrogation and data transmission from the device to the ground should be explored.

Due to the rapid expansion in the number of space objects, space situational awareness provided by traditional, externally derived radar and optical measurements will likely become inadequate for purposes of identification and tracking. A variety of proposals are being discussed to provide a measure of space traffic control under a common authority. Current methods are resource-intensive and prone to errors and misidentifications. For example, multi-satellite launches lead to persistent misidentification of objects launched, and maneuvering satellites are difficult to identify when reacquired by a tracking station. A more robust method is envisioned for identification and tracking of space objects that is collaborative with the objects, paralleling the Automatic Identification System (AIS) in the maritime domain or the Automatic Dependent Surveillance-Broadcast (ADS-B) system in the airborne domain.

With variants of this device attached to future spacecraft and other space objects, future space traffic management systems would be able to continuously monitor space traffic, even through orbital maneuvers and gaps in tracking coverage. Satellite constellation operators would be able to utilize this information to plan maneuvers that minimize near-term risks of collision with other objects. This capability would help to minimize the generation of orbital debris, which would reduce the risk of additional, cascading collision events.

PHASE I: Design a prototype RFID or extremely low-power electronic device that would respond with a unique identifier, position, and state of health data when electronically interrogated, or on a systematic basis. Perform modelling and experiments to validate predicted performance of the proposed device. Develop and describe an architecture that allows for transmission of data from the device to the ground, including requisite link budgets, communication protocols, and power utilization consistent with the design. Perform modeling of the final product and evaluate component technologies for performance and availability with an emphasis on minimizing size, weight, and power (SWaP). The Phase I final report shall include a detailed design and performance specifications for an RFID or electronic device to be fabricated and tested in Phase II.

PHASE II: Develop and test prototype devices to be suitable for subsequent transfer to manufacturing. Phase II prototypes would operate autonomously in conjunction with an interrogation source and be compactly packaged in a form factor suitable for commercial sale. At the conclusion of the Phase II base period, the prototype device shall be tested in a real-time environment at large distances on high-altitude terrestrial platforms (i.e., private aircraft, high-altitude balloons). Phase II option period tasks should include the fabrication and test of a minimum of five additional sensors that could be deployed on an orbital space object. Phase II deliverables will include an Interface Control Document detailing requirements for host platforms, and a test report detailing performance results of prototype testing, and comparisons to pre-flight predictions. Deltas between predicted performance and actual performance shall be analyzed and addressed.

PHASE III DUAL USE APPLICATIONS: Commercial application of the devices may provide a backup source of position information and support anomaly troubleshooting for commercial satellite operators, as well as pre-launch commercial vehicle tagging with possible satellite communication network administration. This data could support existing and planned commercial space situational awareness networks, providing data to commercial satellite constellation operators and to government customers.

Military application of the devices may enhance military space situational awareness efforts, including anomaly investigations, as well as constellation and space traffic management of military satellites.

REFERENCES:
1. https://www.washingtonpost.com/business/economy/companies-flood-earths-orbit-with-satellites/2016/07/22/9db2e522-49ee-11e6-90a8-fb84201e0645_story.html

KEYWORDS: Spacecraft, Satellite, Sensors, Electronics, Low-Power Communications, Orbital Debris, Space Traffic Management

DARPA

SBIR 17.1 DIRECT TO PHASE II PROPOSAL INSTRUCTIONS

IMPORTANT NOTE REGARDING THESE INSTRUCTIONS

Offerors responding to DARPA topics listed in this announcement must follow all the instructions provided in the DoD Program Broad Agency Announcement AND the supplementary DARPA instructions contained in this section.

THESE INSTRUCTIONS ONLY APPLY TO PROPOSALS SUBMITTED IN RESPONSE TO DARPA 17.1 DIRECT TO PHASE II TOPICS. Please contact our office if you require Phase II Instructions or Direct to Phase II instructions for another announcement.

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
http://www.darpa.mil/work-with-us/for-small-businesses

Direct to Phase II (DP2)

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 17.1 SBIR Announcement only and does not guarantee the pilot will be offered in future announcements.

ELIGIBILITY

Not all DARPA topics are eligible for a DP2 award. Offerors should read the topic requirements carefully. DP2 topics may accept Phase I and Direct to Phase II proposals or Direct to Phase II proposals only. 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 DARPA Direct to Phase II Announcement Instructions.

REQUIREMENTS

Offerors interested in submitting a DP2 proposal in response to an eligible topic must provide 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. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI).

DARPA will not evaluate the offeror's related Phase II proposal if it determines that the offeror has failed to demonstrate that technical merit and feasibility has been established or the offeror has failed to demonstrate that work submitted in the feasibility documentation was substantially performed by the offeror and/or the principal investigator (PI).

Feasibility documentation cannot be based upon any prior or ongoing federally funded SBIR or STTR work and DP2 proposals **MUST NOT** logically extend from any prior or ongoing federally funded SBIR or STTR work. Offerors interested in submitting a Phase II proposal to DARPA based upon prior or ongoing SBIR or STTR work should contact sbir@darpa.mil for instructions.

System Requirements

Use of the DARPA SBIR/STTR Information Portal (SSIP) is MANDATORY. The registered Corporate Official (CO) **MUST** authenticate into the SSIP (via the DARPA Extranet) to retrieve the 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 17.1 selection period has closed. DARPA extranet accounts will ONLY be created for the individual named as the CO on the Proposal Cover Sheet. Offerors may not request accounts for additional users at this time.

DARPA contractors who are not eligible to receive a Common Access Card (CAC) are required to obtain a digital certificate from an approved External Certification Authority (ECA) vendor.

- If the SBC has or will register for multiple ECAs, one of the registered ECA e-mail addresses MUST match the CO e-mail address (listed on the Proposal Cover Sheet).
- Additional information will be sent to small business concerns (SBCs) selected for contract award

WARNING: The Corporate Official (CO) e-mail address (from the Proposal Cover Sheet) will be used to create a DARPA Extranet account. The same e-mail MUST also be used for ECA registration. Updates to Corporate Official e-mail after proposal submission may cause significant delays to communication retrieval and contract negotiation (if selected).

Notification of Proposal Receipt

Within 5 business days after the Announcement closing, 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. The CO should add this address to their address book and whitelist to ensure all communications are received.

Notification of Proposal Status

The source selection decision notice will be available no later than 90 days after the Announcement close date for DP2 offerors. The individual named as the "Corporate Official" (CO) 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 the selection decision notice. The request must explain why the offeror was unable to retrieve the selection decision notice from the SSIP within the original 30 day notification period.

Debriefing

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

Announcement Protests

Protests regarding the **Announcement** should be submitted in accordance with the DoD Program Announcement section 4.11.

Protests regarding the **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

Human and/or Animal Use

Your topic may 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 were most likely not 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 DP2 award. Please visit http://go.usa.gov/cBtYW to review the Human Use PowerPoint presentation to understand what is required to comply with human protocols and http://go.usa.gov/cBtYd to review the Animal Use PowerPoint presentation to understand what is required to comply with animal protocols. Offerors proposing research involving human and/or animal use are encouraged to separate these tasks in the Technical Volume and Cost Volume in order to avoid potential delay of contract award.

a. **Human Use:** Reference sections 3.12 and 4.7 of the DoD Program Announcement for additional information.
   - 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).
   - For all proposed research that will involve human subjects in the first year or phase of the project, the institution must provide evidence of or a plan for review by an Institutional Review Board (IRB) upon final proposal submission to DARPA. The IRB conducting the review must be the IRB identified on the institution's Assurance. The protocol, separate from the proposal, must include a detailed description of the research plan, study population, risks and benefits of study participation, recruitment and consent process, data collection, and data analysis. Consult the designated IRB for guidance on writing the protocol. The informed consent document must comply with federal regulations (32 CFR 219.116). A valid Assurance along with evidence of appropriate training for all investigators should accompany the protocol for review by the IRB.
   - In addition to a local IRB approval, a headquarters-level human subjects regulatory review and approval is required for all research conducted or supported by the DoD. The Army, Navy or Air Force office responsible for managing the award can provide guidance and information about their component's headquarters-level review process. Note that confirmation of a current Assurance and appropriate human subjects protection training is required before headquarters-level approval can be issued.

b. **Animal Use:** Reference sections 3.11 and 4.8 of the DoD Program Announcement for additional information.
   - For submissions containing animal use, proposals should briefly describe plans for Institutional Animal Care and Use Committee (IACUC) review and approval. Animal studies in the program will be expected to comply with the PHS Policy on Humane Care and Use of Laboratory Animals, available at http://grants.nih.gov/grants/olaw/olaw.htm.
   - All Recipients must receive approval by a DoD certified veterinarian, in addition to an IACUC approval. No animal studies may be conducted using DoD/DARPA funding until the USAMRMC Animal Care and Use Review Office (ACURO) or other appropriate DoD veterinary office(s) grant approval. As a part of this secondary review process, the Recipient will be required to complete and submit an ACURO Animal Use Appendix, which may be found at http://mrmc.amedd.army.mil/index.cfm?pageid=research_protections.acuro_animalappendix

DP2 Award Information

a. **Type of Funding Agreement**. DARPA DP2 awards are typically Cost-Plus-Fixed-Fee contracts.

- Offerors that choose to collaborate with a University must highlight the research activities that are being performed by the University and verify that the work is FUNDAMENTAL RESEARCH.
- Offerors are strongly encouraged to implement a government acceptable cost accounting system to avoid delay in receiving a DP2 award. Phase II contractors MUST have an acceptable system to record and control costs, including procedures for job costing and time record keeping. Items such as overhead and G&A rates WILL require logical supporting documentation during the DCAA review process. Visit www.dcaa.mil and download the "Information for Contractors" guide for more information.
  - Offerors who do not have a cost accounting system that has been deemed adequate for determining accurate costs must provide the DCAA Pre-award Accounting System Adequacy Checklist in order to facilitate DCAA's completion of Standard Form (SF) 1408. The checklist may be found at: http://www.dcaa.mil/preaward_accounting_system_adequacy_checklist.html.
- Offerors that are unable to obtain a positive DCAA review of their accounting system may on a case-by-case basis, at the discretion of the Contracting Officer, be awarded a Firm Fixed Price Phase II contract or an Other Transaction (OT). For definition and information on Other Transactions for Prototype see the Fact Sheet and Other Transactions Guide for Prototype Projects at http://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program. While agreement type (fixed price or expenditure based) will be subject to negotiation, the use of fixed price milestones with a payment/funding schedule is preferred. Proprietary information must not be included as part of the milestones.

b. **Average Dollar Value**. The maximum value of a DARPA DP2 award is $1,500,000 or $1,510,000 if Discretionary Technical Assistance is proposed (see section below).

Communication with DARPA Program Managers (PM)

Offerors participating in the DP2 process may only communicate with PMs during the pre-Announcement period, published at http://www.acq.osd.mil/osbp/sbir/index.shtml and on SITIS once the Announcement has opened. Information regarding SITIS is available directly from https://sbir.defensebusiness.org/.

Discretionary Technical Assistance (DTA)

DARPA has implemented the Transition and Commercialization Support Program (TCSP) to provide commercialization assistance to *SBIR* ***and/or*** *STTR awardees in Phase I* ***and/or*** *Phase II*. Offerors awarded funding for use of an outside vendor for discretionary technical assistance (DTA) are excluded from participating in TCSP.

DTA requests must be explained in detail with the cost estimate and provide purpose and objective (clear identification of need for assistance), provider's contact information (name of provider; point of contact; details on its unique skills/experience in providing this assistance), and cost of assistance (clearly identified dollars and hours proposed or other arrangement details). 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).

Offerors proposing DTA 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 40-page limit of the technical volume and will NOT be evaluated.
3. Enter the total proposed DTA cost, 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. The proposed amount may not exceed $5,000 per year and a total of $10,000 per Phase II contract.

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

Phase II Option

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, DoD Acquisition Program, other Federal agency, or commercialization into the private sector. The statement of work for the Phase II Option MUST be included with the Phase II Technical Volume and should describe Phase II activities, over a 12 month period that may lead to the successful demonstration of a product or technology. The statement of work for the option counts toward the 40-page limit for the Phase II Technical Volume. If selected, the government may elect not to include the option in the negotiated contract.

Commercialization Strategy

DARPA is equally interested in dual use commercialization of SBIR/STTR 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 Technical Volume of each Phase II proposal must include a commercialization strategy section. The Phase II commercialization strategy shall not exceed 5 pages, and will NOT count against the 40-page proposal limit. The commercialization strategy should include the following elements:

1. A summary of transition and commercialization activities conducted during Phase I, and the Technology Readiness Level (TRL) achieved. Discuss how the preliminary transition and commercialization path or paths may evolve during the Phase II project. Describe key proposed milestones anticipated during Phase II such as: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.
2. Problem or Need Statement. Briefly describe the problem, need, or requirement, and its significance relevant to a Department of Defense application and/or a private sector application that the SBIR/STTR project results would address.
3. Description of Product(s) and/or System Application(s). Identify the commercial product(s) and/or DoD system(s), or system(s) under development, or potential new system(s) that this technology will be/or has the potential to be integrated. Identify the potential DoD end-users, Federal customers, and/or private sector customers who would likely use the technology.
4. Business Model(s)/Procurement Mechanism(s). Discuss business models, procurement mechanisms, and, as relevant, commercial investors or partners, and/or licensing/teaming agreements you plan to employ to sell into your targeted markets.
    a. What is the business model you plan to adopt to generate revenue from your innovation?
    b. Describe procurement mechanisms and potential private sector and federal partners you plan to employ to reach the targeted markets/customers.
    c. If you plan to pursue a licensing model, what is your plan to identify potential licensees?
5. Market/Customer Sets/Value Proposition. Describe the market and customer sets you propose to target, their size, and their key reasons they would consider procuring the technology.
    a. What is the current size of the broad market you plan to enter and the "niche" market opportunity you are addressing?
    b. What are the growth trends for the market and the key trends in the industry that you are planning to target?
    c. What features of your technology will allow you to provide a compelling value proposition?
    d. Have you validated the significance of these features and if not, how do you plan to validate?
6. Competition Assessment. Describe the competition in these markets/customer sets and your anticipated advantage (e.g., function, performance, price, quality, etc.)
7. Funding Requirements. List your targeted funding sources (e.g., federal, state and local, private (internal, loan, angel, venture capital, etc.), estimated funding amount, and your proposed plan and schedule to secure this funding. Provide anticipated funding requirements both during and after Phase II required to:

- mature the technology
- mature the manufacturing processes, if applicable
- test and evaluate the technology
- receive required certifications
- secure patents, or other protections of intellectual property
- manufacture the technology to bring the technology to market for use in operational environments
- market/sell technology to targeted customers

8. Sales Projections. Provide a schedule that outlines your anticipated sales projections and indicate when you anticipate breaking even.
9. Expertise/Qualifications of Team/Company Readiness. Describe the expertise and qualifications of your management, marketing/business development and technical team that will support the transition of the technology from the prototype to the commercial market and into government operational environments. Has this team previously taken similar products/services to market? If the present team does not have this needed expertise, how do you intend to obtain it? What is the financial history and health of your company (e.g., availability of cash, profitability, revenue growth, etc.)?
10. Anticipated Commercialization Results. Include a schedule showing the anticipated quantitative commercialization results from the Phase II project at one year after the start of Phase II, at the completion of Phase II, and after the completion of Phase II (i.e., amount of additional investment, sales revenue, etc.). After Phase II award, the company is required to report actual sales and investment data in its Company Commercialization Report (see Section 7.5.e) at least annually.
11. Advocacy Letters (OPTIONAL).* Feedback received from potential Commercial and/or DoD customers and other end-users regarding their interest in the technology to support their capability gaps. Advocacy letters that are faxed or e-mailed separately will NOT be accepted.
12. Letters of Intent/Commitment (OPTIONAL).* Relationships established, feedback received, support and commitment for the technology with one or more of the following: Commercial customer, DoD PM/PEO, a Defense Prime, or vendor/supplier to the Primes and/or other vendors/suppliers identified as having a potential role in the integration of the technology into fielded systems/products or those under development. . Letters of Intent/Commitment that are faxed or e-mailed separately will NOT be accepted.

*Advocacy Letters and Letters of Intent/Commitment are optional, and should ONLY be submitted to substantiate any transition or commercialization claims made in the commercialization strategy. Please DO NOT submit these letters just for the sake of including them in your proposal. These letters DO NOT count against any page limit.

In accordance with section 3-209 of DOD 5500.7-R, Joint Ethics Regulation, letters from government personnel will NOT be considered during the evaluation process.

DP2 PROPOSAL INSTRUCTIONS

A complete DP2 proposal consists of four volumes:

Volume 1: Proposal Cover Sheet
Volume 2: Technical Volume
PART ONE: Feasibility Documentation **(75 page maximum)**
PART TWO: Technical Proposal **(40 page maximum)**
Volume 3: Cost Volume
Volume 4: Company Commercialization Report

Each DP2 proposal must be submitted through the DoD SBIR/STTR Submission Web site by the Announcement deadline. After authenticating, choose "Start New Direct to Phase II Proposal." 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

a. Proposal Cover Sheet (Volume One)

Prepare the Proposal Cover Sheet in accordance with section 5.4 (a) of the DoD Program Announcement Instructions.

b. Technical Volume (Volume Two)

- The Technical Volume upload must include two parts. Label the Feasibility Documentation "PART ONE: Feasibility Documentation." Part Two of the Technical Volume should be labeled "PART TWO: Technical Proposal.
- Begin on page 1 and number all pages of your Technical Volume consecutively. Use no type smaller than 10-point on standard 8-1/2" x 11" paper with one inch margins. The header on each page of the Technical Volume should contain your company name, topic number, and proposal number assigned by the DoD SBIR/STTR Submission Web site when the Cover Sheet was created. The header may be included in the one-inch margin.
- The Technical Volume should cover the following items in the order given below.

VOLUME TWO - PART ONE: Feasibility Documentation

- Provide 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. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results.
- Maximum page length for feasibility documentation is 75 pages. If you have references, include a reference list or works cited list as the last page of the feasibility documentation. This will count towards the page limit.
- Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI).
- If technology in the feasibility documentation is subject to IP, the offeror must have IP rights. Refer to section 11.5 of these DARPA instructions for additional information.
- Include a one page summary on Commercialization Potential addressing the following:
  i. Does the company contain marketing expertise and, if not, how will that expertise be brought into the company?
  ii. Describe the potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.
- DO NOT INCLUDE marketing material. Marketing material will NOT be evaluated.

VOLUME TWO - PART TWO: Technical Proposal

(1) **Significance of the Problem.** Define the specific technical problem or opportunity addressed and its importance.

(2) **Phase II Technical Objectives**. Enumerate the specific objectives of the Phase II work, and describe the technical approach and methods to be used in meeting these objectives.

a) Phase II Statement of Work. The statement of work should provide an explicit, detailed description of the Phase II approach, indicate what is planned, how and where the work will be carried out, a schedule of major events and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal.

b) Human/Animal Use: Offerors proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.

c) Phase II OPTION Statement of Work. The statement of work should provide an explicit, detailed description of the activities planned during the Phase II Option, if exercised. Include how and where the work will be carried out, a schedule of major events and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail.

(3) **Related Work.** Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the offeror, consultants or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The proposal must persuade reviewers of the offeror's awareness of the state of the art in the specific topic. Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number) and (3) date of completion.

(4) **Relationship with Future Research or Research and Development.**
   i. State the anticipated results of the proposed approach if the project is successful.
   ii. Discuss the significance of the Phase II effort in providing a foundation for Phase III research and development or commercialization effort.

(5) **Key Personnel.** Identify key personnel who will be involved in the Phase II effort including information on directly related education and experience. A concise resume of the principal investigator, including a list of relevant publications (if any), must be included. All resumes count toward the page limitation. Identify any foreign nationals you expect to be involved on this project, country of origin and level of involvement.

(6) **Facilities/Equipment**. Describe available instrumentation and physical facilities necessary to carry out the Phase II effort. Items of equipment to be purchased (as detailed in the cost proposal) shall be justified under this section. Also state whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name) and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices and handling and storage of toxic and hazardous materials.

(7) **Subcontractors/Consultants**. Involvement of a university or other subcontractors or consultants in the project may be appropriate. If such involvement is intended, it should be described in detail and identified in the Cost Volume. A minimum of one-half of the research and/or analytical work in Phase II, as measured by direct and indirect costs, must be carried out by the offeror, unless otherwise approved in writing by the Contracting Officer. No portion of an SBIR award may be subcontracted back to any Federal government agency, including Federally Funded Research and Development Centers (FFRDCs). SBA may issue a case-by-case waiver to this provision after review of the DoD component's written justification that includes the following information: (a) an explanation of why the SBIR research project requires the use of the Federal facility or personnel, including data that verifies the absence of non-federal facilities or personnel capable of supporting the research effort; (b) why the Agency will not and cannot fund the use of the Federal facility or personnel for the SBIR project with non-SBIR money; and (c) the concurrence of the small business concern's chief business official to use the Federal facility or personnel. Award is contingent on the sponsoring agency obtaining a waiver.

(8) **Prior, Current or Pending Support of Similar Proposals or Awards.** Warning -- While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous federal program announcements, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

(9) **Commercialization Strategy.** Each DP2 proposal must contain a five-page commercialization strategy as part of the Technical Volume describing the offeror's strategy for commercializing this technology in DoD, other Federal Agencies and/or private sector markets. See Commercialization Strategy section above for required strategy elements. The commercialization strategy will NOT count against the 40-page proposal limit.

c. Cost Volume (Volume 3)

Offerors are REQUIRED to use the online Cost Volume (https://sbir.defensebusiness.org/) for the Phase II and Phase II Option costs. The Cost Volume (and supporting documentation) DOES NOT count toward the 40-page limit of the Technical Volume. Phase II awards and options are subject to the availability of funds.

The Phase II Base Cost Volume must not exceed the maximum dollar amount of $1,000,000 (24 months) or $1,010,000 if DTA is proposed. Offerors proposing a Phase II Option must also submit a Phase II Option Cost Volume, not to exceed $500,000 (12 months). The total Phase II cost volume must not exceed $1,500,000, or $1,510,000 if DTA is proposed.

Some items in the Cost Breakdown Guidance may not apply to the proposed project. If such is the case, there is no need to provide information on each and every item. What matters is that enough information be provided to allow DARPA to understand how the offeror plans to use the requested funds if the contract is awarded.

1. List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
2. Special tooling and test equipment and material cost may be included. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DoD Component; unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DoD Component.
3. Cost for travel funds must be justified and related to the needs of the project.
4. Use the "Explanatory Material Field" in the DoD Cost Volume worksheet to provide details on subcontractor, material and travel costs, if necessary.
5. Cost sharing is permitted for proposals under this Announcement; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a DP2 proposal.
6. Costs for the base and option (if proposed) are clearly separated and identified in the cost volume.
7. Include the cost of each ECA to be purchased. Reimbursement is limited to a maximum of three ECAs per company. See Contract Requirements section below for additional information.
8. If proposing DTA, include cost in accordance with instructions in DTA section above. Cost cannot exceed $5,000 per year ($10,000 total).

If selected for award, the offeror should be prepared to submit further documentation to the DoD Contracting Officer to substantiate costs (e.g., a brief explanation of cost estimates for equipment, materials, and consultants or subcontractors). For more information about the Cost Volume and accounting standards, see the DCAA publication called "Information for Contractors" available at http://www.dcaa.mil/audit_process_overview.html.

d. Company Commercialization Report (CCR) (Volume 4)

All offerors are required to prepare a CCR in accordance with section 5.4.e. of the DoD Program Announcement.

Modifications or Withdrawal of Proposals

Modification
Late modifications of an otherwise scientifically successful proposal, which makes its terms more favorable to the Government, may be considered and may be accepted.

Withdrawal
Proposals may be withdrawn by written notice at any time. Proposals may be withdrawn in person by an offeror or his authorized representative, provided his identity is made known and he signs a receipt for the proposal.

PHASE II EVALUATION CRITERIA

DP2 proposals will be evaluated in accordance with section 8.0 of the DoD Program Announcement. Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

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 Agreement 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."

CONTRACTUAL REQUIREMENTS

External Certification Authority (ECA)

Offerors must include, in the Cost Volume, the cost of each ECA proposed to be purchased in order to be reimbursed for the cost of ECAs. Reimbursement is limited to a maximum of three ECAs per company. The cost cannot be subject to any profit or fee by the requesting firm.

Offerors should consider purchasing the ECA subscription to cover the Phase II period of performance, to include the option year. Offerors will only be reimbursed for ECA costs once per subscription. Offerors that previously obtained a DoD-approved ECA may not be reimbursed under any potential SBIR/STTR Phase II contract. Likewise, offerors that are reimbursed for ECAs obtained as a requirement under an SBIR/STTR Phase II contract, may not be reimbursed again for the same ECA purchase under any subsequent government contract. Additional information regarding ECA requirement may be found in section 1.0, System Requirements.

Security Requirements

If a proposed effort is classified or classified information is involved, the offeror must have, or obtain, a security clearance in accordance with the Industry Security Manual for Safeguarding Classified Information (DOD 5220.22M).

Payment Schedule

Payment will be made in accordance with General Provisions FAR 523.216-7, *Allowable Cost and Payments.*

Phase II Reports

All DARPA SBIR 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 II contract.

DARPA SBIR 17.1 Topic Index

*These instructions **ONLY** apply to **DP2** Proposals. For Phase I, refer to the DARPA 17.1 Phase I Topics and Proposal Instructions available at (http://www.acq.osd.mil/osbp/sbir/index.shtml).*

		Proposals Types Accepted	
Topic	**Topic Title**	**Phase I**	**DP2**
SB171-001	New Platforms for High-Throughput Culturing and Analysis of Microbial Communities	YES	YES
SB171-002	Automated Environmental and Biological Threat Identification System	YES	YES
SB171-003	New Platform Technologies for Viral and Therapeutic Evolution Assays	YES	YES
SB171-004	Applying Novel Materials and Fabrication Techniques to Thermionic Energy Conversion	YES	YES
SB171-005	Discovery	YES	YES
SB171-006	Code Interposition Framework for Mobile Cyber Applications	YES	NO
SB171-007	Modeling Human Dimensions of the Cyber Ecosystem	YES	YES
SB171-008	Harnessing Open-Source Signals for Detection of Systematic Intervention in Online Discourse	YES	YES
SB171-009	Force Protection in the Online Information Environment	YES	YES
SB171-010	Ultra-Compact Power Conditioning System for High Power RF Transmitters	YES	YES
SB171-011	Recommender Systems for Streaming Data Environments	YES	YES
SB171-012	Non-linear Adaptive Optics	YES	YES
SB171-013	Load Bearing Thermal Protection Structure for Hypersonic Flight	YES	YES
SB171-014	Adaptive Control and Advanced Sensing for Turbine Based Combined Cycle Vehicles	YES	YES
SB171-015	Spacecraft Identification Device	YES	NO

DARPA SBIR 17.1 Topic Descriptions

SB171-001 TITLE: New Platforms for High-Throughput Culturing and Analysis of Microbial Communities

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop and demonstrate novel, high yield, and high throughput multiplexed platforms for culturing and analysis of microbes from microbial communities.

DESCRIPTION: There is a critical DoD need to understand and precisely engineer microbial communities. Microbes hold promise as untapped sources of therapeutic molecules and may be leveraged for a range of industrial applications from medicine to mining. Better understanding of microbial communities would enable the manipulation of the diverse environments in which they are found. Microbial communities are increasingly appreciated as rich sources of natural products and rare metabolic activities, and as key contributors to the health and behavior of the ecosystems they inhabit. The microbial diversity of earth is estimated to be as high as 10^12 species, only 10^4 of which have been sufficiently characterized to be exploited for biotechnology. This relatively small sample of characterized species is in part due to the difficulty of cultivating most microbial species using standard culturing techniques. Technical challenges for culturing microbes include the need for specific growth environments, and a dependence of the microbes on community and host interactions, and minimal culture density. Recent successful efforts to cultivate “unculturable” species by closely mimicking natural environments in the lab have been tailored towards individual species and/or communities of interest. The positive results of these efforts illustrate the feasibility of increasing the number of cultivable species, but ultimately the approaches have been too ad hoc and labor intensive to keep pace with the growing demand for microbiome studies.

DARPA seeks general experimental platforms to enable the high-throughput cultivation and functional characterization of microbial communities from a wide range of environments. The proposed solution should increase the number of unknown species that can be separated, identified, and cultivated from microbiomes by three orders of magnitude relative to standard lab techniques, such as colony growth on petri dishes. The proposed technology should also facilitate analysis of microbial community interactions, such as metabolic contributions of individual species, host interactions, and environmental factors that influence community function and behavior. As such, the proposed technology should be compatible with standard analytical techniques used to study and identify microbial species, including but not limited to next generation sequencing, quantitative polymerase chain reaction (qPCR), mass spectrometry, fluorescence activated cell sorting (FACS), and fluorescent in situ hybridization (FISH).

PHASE I: Develop a breadboard system to demonstrate feasibility of approach for improving yield of culturable microbes. Evaluate performance of system with mock microbiome communities. Deliverables include a detailed design and manufacturing plan and a Phase I final report.

PHASE II: Develop a system prototype and demonstrate enhanced ability to separate, identify, and cultivate microbial species from microbiomes. Platform prototype performance will be evaluated with multiple environmental and microbiome samples and must demonstrate the ability to increase the number of culturable species by three orders of magnitude relative to traditional methods. Deliverables include three standalone prototype systems for independent government evaluation, performance test results, and a Phase II final report.

PHASE III DUAL USE APPLICATIONS: This platform has the potential to become broadly available to microbiology researchers in industry, government, and academia.

REFERENCES:

1. J. Bacteriol. 2012, 194, 4151-4160.

KEYWORDS: microbiome, microbiology, biotechnology, microbial communities, microbes

SB171-002 TITLE: Automated Environmental and Biological Threat Identification System

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical, Information Systems

OBJECTIVE: Develop a handheld platform for real-time identification of a wide range of insect, plant, and reptile (e.g., snake) species that may be found in DoD areas of operation.

DESCRIPTION: There is a DoD need to provide warfighters with tools to support identification of various environmental and biological threats that may be found in their areas of operation. Early identification of potentially harmful insects, plants, and reptiles in the surrounding environment could help to improve safety and maintain maximal physical health of DoD associated personnel. Among other things, such identification tools could help to stop or reduce disease outbreaks or infestations and direct warfighters away from poisonous plants such as the common Toxicodendron radicans (poison ivy). Complicating current efforts is the fact that the number of species of interest in a given area is immense, and even few experts have the necessary training to correctly identify all potential threats across varied geographic regions. There is no current lightweight, accessible, commonly-used solution to the identification problem.

This SBIR topic will support the development of an automated visual recognition and identification system that will (1) provide the image processing capability necessary for characterization of user-submitted pictures of insects, plants, and reptiles, (2) correctly identify dangers, and (3) provide users with relevant and sufficient information to allow for informed decision-making. Importantly, the image processing algorithms and information databases will be contained on a small (e.g., thumb-drive sized) device that interfaces directly with smartphones or similarly ubiquitous technology with image-acquisition capabilities, so that identification can take place on-the-spot in environments without internet connectivity. In addition to remote capability, devices will also wirelessly link to a public, web-accessible database that will synchronize with all devices in-the-field (when connections are available). The development of a master database of field-imaged data will be annotated by subject matter experts who can provide necessary information. As the databases grow with contributions from users, machine learning techniques will be used to improve the identification capabilities. Work in this area will benefit from recent advances in machine learning, image processing, and visual bioinformatics that allow for rapid and automated insect, plant, and reptile identification.

PHASE I: Create a small memory storage device that interfaces with common imaging-capable smartphones or similarly sized battlefield equipment, and an associated app that provides access to the device camera and read/write capability. Build the necessary infrastructure to support a web-accessible database of plant, insect, and reptile images. Ensure that the mobile app and storage device can synchronize with the master database. Demonstrate synchronizing capability by uploading/downloading images from/to various devices. Populate initial database with existing images from reputable university and museum collections. Create the necessary algorithms for image processing and demonstrate positive identification (>90% success rate) of plants, insects, and reptiles from additional high-quality complete photographs not in the original dataset. Establish what information would be relevant to users and provide in an easily distilled format. Phase I deliverables will include detailed designs of the memory storage device and a working prototype, app source code, algorithms, web-accessible curated database of plant, insect, and reptile images, and a final report that includes a detailed and clear description of the algorithms implemented, justifications for choices made with respect to user-relevant information, demonstration test data, and preliminary performance results.

PHASE II: Expand the image library by compiling additional images taken from various locations. Create machine learning algorithms that improve the success rate to >95%. Demonstrate positive identification of the same sample species in a range of light conditions and backgrounds. Demonstrate successful identification using photographs of samples that are incomplete (e.g., insect samples with wings missing or legs broken). Characterize robustness of the device to various environmental conditions (e.g., heat, water). Required Phase II deliverables will include additional source code for machine learning algorithms and other software components added since Phase I, expanded database with geographic information included (if not previously), and a final report that includes description of any changes made to the database, demonstration of success rate improvement, and characterization of device performance in specified environmental conditions. Report should also include a discussion of the potential to expand the scope of the technology to cover fish, birds, and other wildlife that, due to their sensitivity to physical, chemical, and biological threats, may provide indicators to harmful environmental conditions.

PHASE III DUAL USE APPLICATIONS: A successful mobile platform for real-time insect, plant, and reptile species identification has significant potential to transition rapidly to the commercial sector for use in DoD and industrial applications. Users in various environments and in a wide variety of roles—including Environmental Science/Engineering Officers in the field—stand to benefit from the support such a platform will provide in assessing potential environmental and biological risks.

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KEYWORDS: automated visual identification, insect identification, plant identification, medical entomology, pattern recognition, machine learning, bioinformatics

SB171-003 TITLE: New Platform Technologies for Viral and Therapeutic Evolution Assays

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Design and develop new bioreactor technology suitable for long-term assays of cellular and viral evolutionary dynamics, emulating human-like continuous conditions. Demonstrate and validate the technology in a relevant application.

DESCRIPTION: There is a critical DoD need to capture long-term evolutionary dynamics of viral mutations in the laboratory under human-like conditions to aid in the design of evolving therapies (See DARPA INTERCEPT program [1]) and to assess efficacy of these and traditional static therapies in an evolutionary environment. The state-of-the-art approach to tracking long-term viral dynamics is flask-based serial passaging, which continually transfers a small fraction of the viral output from a given flask of infected cells onto a new flask of uninfected cells. Although a powerful technique, the serial passaging method has significant limitations: low abundance viral mutants often are discarded, dilution affects cell and virus characteristics, the rate of viral evolution is prolonged, and the long-term in vivo evolutionary dynamics are not recapitulated. Maintaining appropriate cell influx and viral efflux rates in the face of viral amplification is key to recapitulating virus-host dynamics; this dynamic state is required to determine the instantaneous and steady state in virus stocks and host cell infection status (e.g., infected, uninfected, dying), which in turn is used to monitor virus mutation. One of the central challenges to overcoming these limitations is to design filters or other methods to controllably and quantitatively remove desired cells and virions.

DARPA seeks to promote the design and development of new bioreactor technology to support long-term evolutionary studies for chronic infectious or non-infectious diseases. The reactor must have continuous operation and support controllable rates on influx of fresh cells and nutrient media and the separation and removal of viral particles and different types of cells without clogging or fouling. Removed particles and cells must be sorted by their type. The reactor must support operation for sustained periods of time (minimum of 45-90 days). The system must support controlled "sampling" of the reactor contents one or more times per day. The sample should be unbiased and support additional assays of cells and supernatant such as high-throughput sequencing, molecular imaging, single cell analysis, etc. The filtering technology for removal and sorting should be characterized and validated. Designs should leverage advances in microfluidics, continuous flow, novel filtration mechanisms, or other relevant technologies. The implementation of real-time monitoring methods (i.e. optical methods) are strongly encouraged. Bioreactor systems that effectively combine more than one phase (gas, liquid, solid) or include 2- or 3-dimensional tissue-like structures will be considered favorably.

PHASE I: Develop key requirements (including ranges of influx and efflux rates gathered from published literature) and establish performance metrics for evaluation of the bioreactor. Define the components and methods to be used for filters, sorting, and other parts of system. Investigate and define risks and risk mitigation strategies. Implement a basic prototype system or a simulated system that demonstrates operating principles and fundamental performance capabilities. Establish use cases. Required Phase I deliverables will include a final report detailing the design of the bioreactor system, requirements, fabrication process, and preliminary performance results.

PHASE II: Finalize the design of Phase I and complete implementation. Evaluate the performance of the system against requirements of rates, sorting, sampling, and constraints. Demonstrate and validate the technology in at least one of the following applications: mutation dynamics in candidate viral evolution, the co-evolution of a virus and an associated therapeutic interfering particle, viral, bacterial or cellular evolution under selection pressure from antiviral drugs, immune agents, antibiotics, or anti-cancer drugs. Demonstrate continuous operation for 45-90 days with one sampling every week. Through appropriate statistical analysis of the samples, demonstrate the similarity of bioreactor dynamics to human-like conditions. Phase II deliverables will include final bioreactor design and working prototype and a final report detailing system performance for the selected application.

PHASE III DUAL USE APPLICATIONS: The end goal of this effort is to provide the community with a new type of continuous bioreactor to recapitulate human-like conditions for the study of long-term evolutionary dynamics of fast mutating pathogens, diseases and emerging pandemics of interest to DOD. The new platform technologies developed under this SBIR are expected to support investigation and design of evolving therapies such as therapeutic interfering particles. This bioreactor will also be useful to identify pathogen mutations that can escape therapies, understand the evolution of cancer cells, and dynamically track effects of therapy.

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KEYWORDS: Bioreactor, evolutionary dynamics, continuous flow, filters, mutations, viral escape, long term assay

SB171-004 TITLE: Applying Novel Materials and Fabrication Techniques to Thermionic Energy Conversion

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Electronics, Materials/Processes

OBJECTIVE: Develop efficient, power-dense thermionic materials and device structures that leverage recent advances in novel device design, novel cathode and anode materials, and recent advances in semiconductor physics. Apply these advances to thermionic converters, improving their performance in terms of power densities (>10 W/cm2), conversion efficiencies (>25%), and lifetimes (>5 years).

DESCRIPTION: There is a critical DoD need to develop efficient, power-dense energy conversion materials and device structures, particularly, thermionic converters, whose thermal-to-electricity conversion efficiency is greater than competing mechanical engines. An example of thermionic energy conversion relates to the electron tube where electrons are "boiled off" a hot cathode into a vacuum and collected by the anode, resulting in electrical current. The properties of the thermionic materials used to make the cathode and anode and the internal structure of the converter limit the energy conversion efficiency and power density of the conversion process. While the field of thermionics has been around for decades, recent new materials, device designs and semiconductor fabrication techniques offer the opportunity to improve these converters, transforming long-established capabilities of thermionics in terms of the power densities, the conversion efficiencies and the lifetimes for converting heat to electricity.

PHASE I: Use novel thermionic materials and structures to design an energy converter with no moving parts whose power is scalable from watts to kilowatts. Determine key requirements and establish performance metrics for evaluation. Define thermionic materials properties and converter architectures that satisfy the fabrication process requirements. Investigate and define risks and risk mitigation strategies. Implement a basic prototype system that demonstrates operating principles and fundamental performance capabilities.

Required Phase I deliverables will include a final report detailing the design of the converter system, requirements, fabrication process, and results of the investigation into candidate materials and converter designs.

PHASE II: Finalize the design of Phase I and complete fabrication of a packaged thermionics energy converter. Evaluate the performance of the standalone system against process requirements and manufacturing and reliability constraints. Integrate materials with specific converter design defined in Phase I. Implement the fabrication process established in Phase I and demonstrate operating performance. Include risks and risk mitigation strategies to the design. Establish use cases and trade-offs for each use case. Validate design with performance testing to pre-defined performance metrics. Evaluate quality and robustness of thermionic materials. Evaluate improvements over state-of-the-art solutions.

Required Phase II deliverables will include a final report and a demonstration of the thermionic converter.

PHASE III DUAL USE APPLICATIONS: The end goal of this effort is to provide the community with thermionics materials and converters whose thermal-to-electricity conversion efficiency is greater than competing mechanical engines. Such materials and converters could be applied to man-portable systems, unmanned autonomous aerial systems, unattended ground sensors, and other systems where heat sources are readily available.

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KEYWORDS: thermionic energy conversion, work function, vacuum electronics, anode, cathode

SB171-005 TITLE: Discovery

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop transformative knowledge navigation and document discovery software with the ability to analyze complex, multi-faceted data sets and provide the user with an intuitive interface that shows patterns and connections within the data regardless of data size or file type.

DESCRIPTION: There is a critical DoD need for new software tools that can rapidly ingest and index large data sets from archived data to provide users with methods to quickly survey and harvest pertinent information. The increasing number and size of data archives has stockpiled vast quantities of information. While the extent of archiving is viewed positive, the retrieval tools enabling rapid survey and use of the archived information have not kept pace. This data explosion opens new opportunities to extract more value from data collected by the military, academia and industry. According to research by MGI and McKinsey's Business Technology Office, big data analysis is becoming the key basis of competition due to the increasing volume and detail of information captured by enterprises, multimedia, social media and the internet. In the commercial sector, big data can be transformative through the collection of product performance, consumer and market trend information. The ability to cultivate, analyze and display this information as meaningful output will enable organizations to make decisions regarding future investment areas.

The endeavor of making archives useful, is still underdeveloped. Search engines are one of the major strategies to cull through archived data, but only yield lists of information. Search engines do not enable the user to rapidly understand the topics embedded within the archive nor make connections between topics. Some content management tools that can search for keywords and return a list of matching files are available, but often require the user to know precisely what they are seeking. These tools fail to enable the user to explore the data archive in an organized approach. These aforementioned liabilities are particularly acute for archival systems designed to meet security requirements.

The tools that have been developed to parse and search through large datasets have not been able to incorporate growing datasets and provide applicable, useful information using visualization techniques that achieve the desired level of interactivity. A software tool that can adapt to datasets of different volumes and compositions, provide the user with the desired output and implement visualization techniques that make the system accessible is needed to deal with the rapid increase in archived data. Tools that can analyze and produce output that displays patterns, connections and actionable information for the user will be increasingly useful. The proposed system would create a collaborative platform that is not only content-rich, intuitive, and useful, but also widely applicable and customizable. The platform will create a process that can rapidly analyze structured and unstructured datasets to query, identify and visualize hidden values.

PHASE I: Analyze existing archival systems and visualization techniques that can be leveraged and improved to meet the topic objective. Conduct an analysis and create a model of a data visualization application from an existing large dataset that estimates the minimum number of assets that are required to create a viable, interactive and scalable system. Phase I deliverables include application source code, preliminary performance results, and a final report.

PHASE II: Create a data visualization software application prototype with the following capabilities: 1) can be implemented at different levels of secure environments; 2) easily ingest datasets ranging from 10,000-10,000,000 documents of varied file types; 3) index the datasets with the potential for daily, weekly or monthly updates; 4) and an innovative indexing feature adaptable to non-structured and structured datasets. The user interface for the application must meet the following requirements: 1) intuitive to navigate with no training; 2) display the data in organized categories; 3) enable users to modify the number and type of categories; 4) highlight connections between categories; and 5) display trends in the data.

Conduct market analysis of two potential areas of insertion, which includes a description of how the targeted users impacted the design and functionality of the system. Phase II deliverables will include a product that is ready for beta release for market testing, a preliminary commercialization plan, and final report.

PHASE III DUAL USE APPLICATIONS: At the conclusion of the SBIR effort, potential military partners such as the Office of Naval Research and the Army Research Office, should be contacted for interest in adopting the innovative software platform to enable increased access to pertinent information embedded in archived data. Other military organizations such as US Army Medical Research and Materiel Command (USAMRMC) could also use the technology to rapidly index their large datasets and provide a user-interface that enables the user to extract more information than the current indexing tools.

Commerical applications such as large businesses that are collecting purchasing information could use this technology to parse through their large quantities of data and display consumer information in a more meaningful and useful way.

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KEYWORDS: Data visualization, knowledge management, data archival software, information design, knowledge navigation, document search, design of data

SB171-007 TITLE: Modeling Human Dimensions of the Cyber Ecosystem

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Human Systems, Information Systems

OBJECTIVE: Represent and analyze human behaviors within a cyber ecosystem (consisting of software, hardware, and human users) to support assessment of overall ecosystem security.

DESCRIPTION: There is a critical DoD need to develop computational models and tools to represent and analyze human capabilities and behaviors (e.g., attention management, information processing, error, workload, cognitive biases, social learning) that affect the security of a cyber ecosystem – that is, the overall sociotechnical system consisting of humans, software, hardware and their interrelationships. Computational models and tools for representing and analyzing the human dimensions of security should be used as part of a broader verification process to assess a cyber ecosystem's overall security. Assessments of cyber ecosystem security that integrate an understanding of human capabilities and behaviors will result in more accurate decisions regarding whether a system is adequate for specific applications, and will help guide remediation efforts such as the development of security policy modifications, personnel training plans, and specific technological countermeasures.

Risk assessment for conventional cyber security focuses on formally proving that software has no vulnerabilities (e.g., buffer overflows or cross-site scripting) and/or systematically testing with less formal verification processes (e.g., assessing architectural design and known software vulnerabilities through scans, performing analysis of static/dynamic code). Other cyber security efforts focus on creating computing hardware that resists various forms of exploitation. However, even when software and hardware vulnerabilities are eliminated, the interaction of humans with that software and hardware can lead to new and unexpected vulnerabilities. The range of relevant forms of human interaction with a system is broad, spanning not only the end-users of systems, but also system and network administrators, policy makers, system designers, malicious actors external or internal to the organization, as well as the various types of behaviors exhibited by each. Securing an overall cyber ecosystem must therefore address the potential for vulnerabilities that could be introduced from across all forms of human interaction with the system. If the human capabilities and behaviors that exist within a cyber ecosystem could be accurately represented in computational form, the security of any such system could be rapidly assessed during and after development.

This effort will develop a modeling framework that supports integration of diverse data sources from the cyber domain and inferred human capabilities and properties (e.g., psycho-social factors, patterns of life, cognitive and perceptual factors) to enable the creation of models of human behavior within the cyber ecosystem, as well as the rigorous validation of such models. The models should reflect a wide range of vulnerabilities, ranging from the unintentional and careless to dedicated adversarial behaviors. The effort must include modeling human behavior beyond the user interface—the goal is not to merely confirm the functionality of the user interface, but rather the inherent complexity found when multiple humans are interacting in a variety of ways with a system and each other.

This effort will marry research in modeling human behavior with formal security analysis methods to identify system vulnerabilities that are "reachable" given varying levels of human intentional and unintentional behavior. One result of this work will be an assessment of the likely risk of activating the human-associated vulnerability for a system and its operational policies. This approach will provide additional and immediate benefits through the assignment of monitoring resources, training, improvements to cyber technologies, and/or revisions in security policies to improve resilience against the highest value threats.

PHASE I: Prototype a framework for assessing overall security of a cyber ecosystem by combining models of human behavior with models of cyber infrastructure (software, security systems, security policy). Design computational methods and models to represent and analyze cyber-relevant human behaviors. Demonstrate plausible approaches to acquire those computational models from existing and/or new data sources. Develop a plan and metrics for validating models against real-world data and/or experiments, and assessing the utility of the models for cyber ecosystem security evaluation. Phase I deliverables will include a final report including a description of validation plans for Phase II and a demonstration of the prototype human behavior model(s).

PHASE II: Implement the framework for assessing overall security of a cyber ecosystem using models of human behavior and cyber infrastructure. Develop a scalable implementation of computational models of human behavior, and enhance with the results of data collection/experimentation. Perform ongoing, frequent validation and utility assessment of models and model components against real-world data as per the Phase I plan. Phase II deliverables will include software and technical reports, and a final report with recommendations for transitioning the models to operational systems.

PHASE III DUAL USE APPLICATIONS: Potential U.S. Government stakeholders and transition partners include DoD acquisition programmatic test and evaluation labs, United States Cyber Command and their Service components. However, cyber security is far from a military-only concern. Commercial organizations generally face a more difficult security risk situation due to lack of control and influence over both their members and the hardware and software systems they use. Therefore, they have a greater need for organization-wide security posture assessment tools—and the technologies developed in this effort will be equally applicable to military and commercial analyses.

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KEYWORDS: cybersecurity, vulnerabilities, human behavior modeling, software verification, model validation, trust

SB171-008 TITLE: Harnessing Open-Source Signals for Detection of Systematic Intervention in Online Discourse

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Human Systems, Information Systems

OBJECTIVE: Develop a generalizable approach and enabling software for detecting and analyzing systematic interventions in online discourse.

DESCRIPTION: There is a critical national security need to understand the priorities of other governments, a task that is particularly difficult when dealing with opaque, authoritarian systems. The U.S. has important relationships with countries that engage in information control practices (e.g., restricting freedom of the press), which make discerning the policy goals of leadership difficult. Policy discussions are not held in public forums, official statements tend to be broad or vague, and local media is frequently subject to strict publication limitations. However, regimes that exert great effort in managing the flow of information also tend to engage in similar and complementary information control practices online. The Internet has provided many platforms to share news and ideas in an unregulated manner, even in countries where the information environment is closely regulated. Government efforts to control the flow of information online (via tactics such as censorship, sock-puppeting, and/or astroturfing) leave an imprint that can be measured and interpreted as a representation of which topics or people are considered important to those in power.

Comprehensively tracking systematic efforts to control information is a significant technological challenge, particularly in the diverse, voluminous, shifting, and multilingual online environment. To accurately track online interventions, the action of foreign governments must be studied at high speeds and on large scales with multiple algorithms designed to consistently detect online intervention and correlate trends, given that "ground truth" - by design - is hidden. To make sense of the signal at scale, these algorithms will require automated text analytic techniques tailored to the target language, baselining and trend detection methodologies, topic modeling, and regional or sub-national analysis. This effort seeks to develop an ensemble of generalizable approaches and associated algorithms for detection of online interventions in discourse – and is focused on text (although extensions that address audio, imagery, and/or video are not excluded). Generalizing approaches is challenging, given the need to accommodate: (1) different and dynamic languages and media consumption patterns; (2) ongoing changes in a foreign government's topical interests and tactics; and (3) the wide variety of means by which information flows online.

This effort will include the identification and/or extraction of publicly available information from foreign online media and social networking sites that contains one or more signals created by the online intervention of foreign governments. Identification and extraction efforts are difficult for a variety of reasons, including the multitude of forums to monitor, the need to identify posts in near-real time to ensure they are collected before they are altered or removed, and the need to systematically separate relevant content from irrelevant content that might be altered or removed (e.g., spam). Successful implementation will depend on two aspects working in harmony:
(1) comprehensive data identification and/or extraction infrastructure adaptable to different regions; and
(2) robust and regionally sensitive post-collection analysis.

The effort will ensure compliance with all relevant policies and regulations on the protection of human subjects in research.

PHASE I: Develop a system design concept to identify, extract, and analyze one type of online intervention in a single country, including the infrastructure for obtaining and analyzing at least two sources of anonymized, foreign social media data. Acquire data. Demonstrate approach to analyzing online intervention, including demonstration of all system components and analytic products. Phase I deliverables will include a final report that describes measured instances of online content manipulation and a replicable research approach, as well as the design of a software architecture.

PHASE II: Apply the Phase I proof of concept to another country to test the prototype's ability to observe and quantify online intervention in a locale-agnostic manner. After multi-region data acquisition, apply regionally sensitive detection algorithms for each national data set and refine to produce accurate results across data sets. Evaluate software's ability to correlate online intervention with real-world events and policy-relevant subjects. Test ability to develop sub-national (regional) tuning. Phase II deliverables will include software and technical reports, including a final report containing recommendations for transitioning the models to operational systems.

PHASE III DUAL USE APPLICATIONS: The resulting technology has potential to commercialize into the financial industry, particularly investors who pursue international partnerships and need new sources of information on in-country events and government posture. The DoD and other federal agencies have considerable interest in improving awareness of foreign government policy priorities, particularly for opaque regimes who practice tight information control. Therefore, the resulting technology has potential to transition to agencies whose mission is to track which policy areas are the focus of foreign government information control efforts, as well as to monitor changes or trends in those efforts.

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KEYWORDS: online discourse, text analytics, social media, social networking, policy-making

SB171-009 TITLE: Force Protection in the Online Information Environment

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Human Systems, Information Systems

OBJECTIVE: Develop automated software tools that use publicly available information (PAI) to detect intent, within foreign populations, to harm U.S. forces stationed overseas, while ensuring privacy and appropriately addressing personally identifiable information that may be found in PAI.

DESCRIPTION: The DoD is increasingly relying on publicly available information (PAI), including some forms of social media, to develop situational awareness and identify potential threats to overseas forces. Capabilities have been demonstrated to monitor PAI and analyze sentiment, attitudes about specific topics, as well as group properties such as organizational structure, cohesion, and extra-group affiliations. Such attributes can and have been used to monitor the shifting attitudes of groups through their exhibited behavior in social networking environments and other online forums in which such information is openly published. However, a key remaining challenge is determining if exhibited behavior in PAI that appears to have some characteristics of threat behavior actually represents a real threat, or merely some other purpose (venting, appearing agreeable to an affiliated group, etc.). That is, it is a challenge to assess not only if expressed beliefs or attitudes are sincere, but also whether those beliefs or attitudes are a likely source of intentionality and action. This challenge is made more difficult by the potential for a group to act covertly or to practice deception.

This effort will pursue the ability to accurately detect and predict a group's intention to act within expressive behavior in PAI. This effort will consider intention as a phenomenon distinct from attitude or belief expressions themselves. Preference will be given to approaches that hold promise of resilience across differing sources of PAI (e.g., different social networking environments, online news), languages, cultures, and topics. In addition, any successful effort will include a comprehensive plan for ensuring privacy , appropriately addressing personally identifiable information that may be found in PAI, and ensuring that only PAI from foreign populations is considered.

PHASE I: Develop an approach for detecting beliefs, attitudes, or other characteristics of a foreign group and their network that predicts intention to act as a function of communications seen in PAI. Document these characteristics with a clear rationale for why they are likely to help anticipate threatening actions taken against U.S. forces overseas, and for which behavioral and environmental contexts they are likely to be successful. Demonstrate the approach with real or representative data and develop a plan for rigorous validation of the approach in Phase II using multiple data sets and/or non-historical data. Demonstrate that the approach will ensure privacy, address personally identifiable information that may be found in PAI, and ensure only PAI from foreign populations is considered. Phase I deliverables will include a demonstration of the approach for at least one use case, and a final report including a description of validation plans for Phase II.

PHASE II: Design and implement an intent-to-act detector using the approach demonstrated under Phase I. Continuously evaluate and validate the detector on multiple data sets, as per the Phase I plan. Extend the detector across different forms of PAI, cultures, languages, and intended real-world behaviors. Phase II deliverables will include software and technical reports, and a final report with recommendations for transitioning results to operational systems.

PHASE III DUAL USE APPLICATIONS: Potential DoD applications for this technology include protection of U.S. forces in the digital domain, not only to detect potential threats, but also to identify potential lapses in operational security that may occur in the online environment. Potential commercial applications for this technology include: brand marketing, advertising, competitor analysis, and organizational health assessment.

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KEYWORDS: Force protection, social media analysis, intention, beliefs and attitudes, cross-culture study

SB171-010 TITLE: Ultra-Compact Power Conditioning System for High Power RF Transmitters

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Electronics, Weapons

OBJECTIVE: Design and demonstrate an innovative high voltage power supply/modulator utilizing novel components and/or topologies to significantly reduce the size and weight of high power RF transmitters based on vacuum electronics.

DESCRIPTION: There is a critical DoD need to reduce the volume and weight of high power RF transmitter systems. The power supply is a key component of the transmitter. This solicitation seeks to develop the enabling technologies to significantly reduce the footprint and weight of power supplies for transmitters based on vacuum electronic amplifiers and to demonstrate innovative power supply architectures in a relevant application. Vacuum electronic (VE) amplifiers such as traveling-wave tubes (TWTs) often are the technology of choice for transmitter applications requiring operation with high power-bandwidth product performance at microwave and millimeter-wave frequencies. A high voltage power supply/modulator (HVPS/Mod) provides the conditioned voltages and currents to the TWT and is a critical component of the transmitter system. Typically, the HVPS/Mod consists of a cathode supply, heater power supply for the thermionic electron gun, a modulating anode or grid supply to gate the electron beam on and off, and supplies to bias multiple depressed collector stages in a topology that enables true energy recovery of the spent electron beam for overall system efficiency enhancement.

Increasingly, constraints on platform size and available prime power are placing challenges on the volume, weight, and efficiency of the HVPS/Mod. This topic seeks the development and demonstration of new HVPS/Mod topologies and components to significantly reduce the HVPS/Mod system SWaP (size, weight, and power requirements) and to increase the power density up to 1 Watt/cm^3 (>3x the current state-of-the-art). Innovative architectures that can exploit higher switching speeds with low losses are desirable as are the development and incorporation of new materials and components such as (but not limited to) high speed, high voltage solid-state switches and rectifiers; high frequency, high saturation field, low-loss magnetics; compact, high voltage capacitors that can tolerate high ripple currents ; compact high voltage connectors; improved high voltage dielectrics; and improved high voltage packaging and encapsulation.

The overall topic goal is to demonstrate innovative power supply architectures for applications in RF transmitter systems and to develop the enabling technologies to significantly reduce the volume and weight. To provide a focus for the development, the specific performance goals for this topic are a cathode voltage and current of 20 kV and 1.5 A, respectively; 100% duty operation; a maximum modulating anode voltage swing of -3 kV (beam off) to +1.5 kV (beam on) with respect to the cathode voltage; cathode heater DC power of 12 V and 5 A with respect to cathode voltage; and up to four stages of depressed collectors for energy recovery with a goal of reducing the prime power requirement to approximately one third of the beam power.

PHASE I: Conceptualize and design an innovative HVPS/Mod architecture with a power density of up to 1 W/cm^3 and capable of meeting program performance goals. These goals include a cathode voltage and current of 20 kV and 1.5 A, respectively; 100% duty operation; a maximum modulating anode voltage swing of -3 kV (beam off) to +1.5 kV (beam on) with respect to the cathode voltage; cathode heater DC power of 12 V and 5 A with respect to cathode voltage; and up to four stages of depressed collectors for energy recovery with a goal of reducing the prime power requirement to approximately one third of the beam power. The overall HVPS/Mod power-added efficiency should exceed 85%. Key components and enabling technologies will be investigated, assessed, and identified for incorporation in the design.

Phase I deliverables include the HVPS/Mod electrical design and preliminary mechanical design, the identification of innovative component technologies, and a plan for their development and implementation.

PHASE II: Develop, fabricate, and demonstrate a prototype HVPS/Mod based on the Phase I work. Finalize electrical and mechanical engineering designs. As necessary, developmental components and sub-assemblies will be tested and validated. A series of laboratory tests will demonstrate that the prototype hardware meets the power density and electrical performance goals set out in Phase I.

Phase II deliverables include all HVPS/Mod hardware and a report documenting test results and innovative component development.

PHASE III DUAL USE APPLICATIONS: Vacuum electronics is a critical defense technology. At present, over 80% of the microwave and millimeter-wave transmitters in fielded DoD systems are based on vacuum electronic amplifiers and oscillators. Compact high voltage power supply/modulators are a key component for all of these systems and are a critical enabling technology for future applications on land, air, sea, and space-based platforms. These applications include jam resistant high data rate digital communication systems capable of operation in adverse environmental conditions, high resolution radar with extended range, and high power, broad bandwidth transmitters for electronic attack. The HVPS/Mod architectures and advances in innovative component technologies resulting from the Phase I and II research will enable new systems with significantly lower SWaP compared with the current state-of-the-art.

Commercial applications would also benefit from reductions in HVPS/Mod SWaP. For example, the reduced volume and weight would enable higher power transmitters to be mounted directly on ground-based antenna feeds resulting in lower system losses and increased range of operation. Furthermore, the technology could be used in satellite communications. Over 90% of the geosynchronous communications satellites use TWT amplifiers. Reductions in the size and weight of the power supply/modulators would have immediate benefits. For example, reduced SWaP would allow the inclusion of more amplifiers on a given satellite to increase channel capacity and/or improve reliability, or reduce the overall size and weight of the satellite to minimize launch costs.

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7. Additional Topic Briefing, November 30, 2016 (uploaded in SITIS on 11/30/16).

KEYWORDS: vacuum tube electronics, millimeter wave, microwave, amplifier, transmitter, oscillator, power supply, power modulator, traveling wave tube, power electronics

SB171-011 TITLE: Recommender Systems for Streaming Data Environments

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop innovative approaches that enable recommender systems to take advantage of domains where the set of available features changes over time.

DESCRIPTION: There is a critical DoD need to develop “recommender” systems that process data based on streaming rather than static feature sets to more intelligently automate big data analysis and cue pertinent information for analysts and planners. Recommender systems have been a staple of many recent successful businesses including Netflix’s movie suggestions and Amazon’s product recommendations. They are also rapidly emerging in many other fields such as personal health recommendation and can similarly be expected to play a larger role in intelligence analysis and command and control functions of Department of Defense (DoD). For example, such a system could help an analyst cue-in on critical aspects of an image, or serve as a virtual decision-aide in the construction of courses of action during mission planning.

These systems typically work by identifying trends or patterns in data to associate past behavior with future tendencies. For example, based on a given user’s past movie history rankings and what their friends rated highly, a recommender system can generate a short list of movie suggestions that the user will most likely want to watch next. A critical piece of such functionality depends on the features that describe the data; from the above example they would include a user’s movie rating history, network of friends, movie genre, etc. In the past, recommender system designers would hand tune this set of features and it would remain static for months or years, but this approach ignores many other potentially beneficial features that could be found from available data.

Consider the problem of recommending articles posted on social media websites. Typical features would consist of a predefined set of words and topics; however, the language of social media changes frequently. New slang words and event-driven topics may greatly alter the meaning of articles; recommender systems built on fixed feature sets without these words may be unable to keep up with current trends and fail to meet user expectations. This is an example of the need to incorporate streaming features – new words in this example – to improve recommender system performance.

PHASE I: Identify one or more relevant data sources and recommendation targets applicable to those sources. Design an algorithmic approach to enable a recommender system to take advantage of streaming features produced by the identified data source(s). Phase I deliverables must include a final report documenting the data sources considered and the algorithmic approach to be pursued in Phase II.

PHASE II: Implement and demonstrate the algorithm produced in Phase I results in a successful recommender system for the selected problem area. Evaluate the proposed recommender system against recommender systems that use only static (non-streaming) feature subsets to demonstrate potential gains to be achieved by using streaming features. Phase II deliverables must include a prototype software implementation of the algorithm as well as a final report that documents the software, system design, and evaluation results.

PHASE III DUAL USE APPLICATIONS: This effort has the potential to enable several resilient recommender systems to be developed as virtual decision-aides for defense systems (tipping and queuing for intelligence analysts, course of action planning in command and control processes, etc.); and may have a broad impact in the commercial sector (improved product recommendations, tailored newsfeeds, personalized health plans, etc.).

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KEYWORDS: recommender systems, online feature learning, streaming feature selection, machine learning, artificial intelligence

SB171-012 TITLE: Non-linear Adaptive Optics

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Sensors, 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 5.4.c.(8) of the Announcement.

OBJECTIVE: Develop adaptive optics (AO) for beam control of high energy ultra-short pulse lasers (USPLs) propagating through non-linear media.

DESCRIPTION: There is a critical DoD need to develop and demonstrate an adaptive optical beam control system optimized for use with high energy, ultra-short pulse lasers and propagation in non-linear media such as the atmosphere. USPL pulses propagating through a non-linear medium such at the atmosphere undergo self-focusing due to the non-linear interaction between the high-peak-power optical field and the propagation medium[1], and may undergo other non-linear optical interactions, for example (but not limited to) Raman or Brillouin scattering. DARPA is interested in developing adaptive optics which enable precise beam control of non-linear optical beam propagation in uncontrolled turbulent and non-linear media, in particular in the atmosphere. The propagation of high-peak power short pulses is influenced by the spatial, spectral and temporal profile of the pulse.[2] Therefore, “adaptive optics” in this announcement is extended to include or interface with methods of dynamic manipulation of the spectral and temporal profile of the laser pulse as a secondary or augmented capability. The adaptive optical system to be designed shall include a method of spatial wavefront correction (e.g. deformable mirror (DM)), a spatial wavefront sensor (WFS), a diagnostic method of closed-loop feedback (such as a guide beacon), and a closed-loop control system with control software and user interface. The system shall be designed to accommodate short pulse lasers with pulse energies up to 1J, pulse lengths varying from 100fs to 100ps, and peak power levels of 10-1000 GW. The system should be compatible with operation in the near-IR (~0.8-1.1µm), short-wave infrared (1.3-2.5µm), and/or the mid-wave infrared (3.5-4.2µm). The wavefront correction components should be capable of dynamically correcting moderate to high spatial frequency scales such as those expected for optical propagation through a turbulent atmosphere. DARPA desires near-diffraction-limited correction of wavefront errors with spatial frequency less than or equal to 6/(clear aperture), in a clear aperture of 2-8 cm, at rates >100Hz, with a peak-to-valley dynamic range of 6 microns excluding full-aperture tilt. This is approximately equivalent to an ability to compensate for up to the sixth order of aberrations in Zernike polynomials. A means of diagnostic feedback to the closed-loop wavefront control is an important part of the system. It can be assumed for the purpose of this effort that the transmitted USPL pulse will be brought to a self-focus at a predetermined distance. The high-peak-power USPL pulse will experience distortions of non-linear effects during propagation that would not happen to a lower power beam propagating through the same medium when the USPL pulse is not present. Therefore, there is special interest in AO methods which utilize measurements of the USPL focus viewed from the launch aperture location as a diagnostic source.

This is a significant departure from traditional AO systems which rely on direct wavefront sensing and reciprocal symmetry of the propagation path. However, systems which utilize independent wavefront measurements of the linear propagation paths, or other methods, are acceptable if they can obtain some degree of sensing and correction of the non-linear propagation path[4]. Novel control solutions such as “sensorless” methods[3] are of interest to address this issue. In addition, the propagation of a USPL pulse in a non-linear medium can be altered by changing the spectral/temporal profile of the pulse. In atmospheric propagation, for example, analog modulation of the spectral or temporal profile is desired with resolution of 1/10 (or less) of the spectral or temporal width. Consequently, AO closed-loop methods that can interface with spectral/temporal pulse control systems and can utilize such spectral/temporal controls in open- or closed-loop coordination with spatial wavefront control are of particular interest.

PHASE I: Develop a detailed description of the adaptive optical system, including wavefront measurement methods and sensors, wavefront correction methods and materials, and control system methods and algorithms. This description should include a performance estimation of residual wavefront error, closed-loop bandwidth, and a preliminary evaluation of the expected size, weight, and power consumption of a complete prototype system implementation. The Phase I design description should address the ability of the proposed approach to accommodate ultrashort pulsed power levels of up to 100 GW and up to 1J of pulse energy. In addition, the Phase 1 effort should address the control-system approach and provide an analytic validation that the proposed approach can converge to a desired solution in the presence of non-linear optical effects. Phase I deliverables will include a Kickoff Meeting briefing, monthly technical and financial status reports, a Final Review briefing and a narrative Final Report.

PHASE II: Demonstrate the Phase I concept via brassboard experiments. In Phase II, a Phase I concept will be reduced to practice at full scale, and its performance validated in a laboratory setting. The experiments conducted should result in empirical and/or analytic knowledge that may be used to further optimize and/or upgrade the system to a prototype AO system. The laboratory brassboard must provide characterization data that demonstrate by analysis that the performance objectives can be met. It is expected that the brassboard system with minor modifications could be subsequently utilized in a field experiment that would directly meet the performance objectives in the atmosphere. Phase II deliverables will include a Kickoff Meeting briefing, monthly technical and financial status reports, a System Requirements Review briefing and report, an Experiment Plan, a Final Review briefing and a narrative Final Report.

PHASE III DUAL USE APPLICATIONS: AO systems capable of providing beam control for non-linear optical beams may find military applications in high-energy laser systems and in standoff chemical identification systems. Commercial applications may include laser material characterization, processing and manufacturing with ultra-short pulse lasers, medical imaging, and optical communication.

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5. Additional Topic Briefing, December 7, 2016 (uploaded in SITIS 12/7/16).

KEYWORDS: adaptive optics, ultrashort pulse laser, nonlinear optics, atmospheric propagation, self-focusing, beam control, nonlinear propagation

SB171-013 TITLE: Load Bearing Thermal Protection Structure for Hypersonic Flight

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Air Platform, Materials/Processes

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 5.4.c.(8) of the Announcement.

OBJECTIVE: Develop and demonstrate lightweight, low-cost, load-bearing thermal protection structure for hypersonic flight.

DESCRIPTION: There is a critical DoD need for penetrating intelligence, surveillance, and reconnaissance (ISR) for which hypersonic cruise vehicles may be a potential solution. Hypersonic cruise vehicles require the use of high-temperature resistant materials to withstand the high thermal fluxes and integrated thermal load during flight. The focus of this SBIR is on air-breathing hypersonic cruise vehicles in the Earth’s atmosphere. In order to achieve manufacturing and maintenance cost savings as well as weight reduction, structural concepts for a load-bearing thermally protected structure are needed. Structural concepts for hybrid thermal protection systems (TPS) and hot structure components, including leading edges, aerodynamically heated remaining structure, and control surfaces are sought to improve on the state-of-art. The current state of the art in hypersonic structures faces two technical challenges: environmental durability and fabrication; additionally, weight penalty is incurred since the TPS is parasitic and not load-bearing. System mass, conformal shape, manufacturing costs and complexity of structure become important where state of the art structural concepts fall short of meeting envisioned future mission requirements.

PHASE I: Define the specific performance goals for the proposed load bearing structure based on the intended class of structural components for hypersonic vehicles. Provide detailed rationale for the concept in terms of cost and weight savings. Perform preliminary design of the structural part. Predict thermomechanical performance by low-fidelity analysis and compare performance to government provided data on existing TPS/hot structures. The Phase I final report will include a manufacturing and experimental evaluation plan to be executed under Phase II.

PHASE II: Finalize, fabricate, and validate a load-bearing thermal protection structure for a class of hypersonic aircraft parts. Quantify manufacturing cost for low-rate and intermittent-demand production. Execute the experimental plan developed under Phase I to evaluate relevant thermomechanical properties in a laboratory environment simulating critical application requirements. Work with government team to identify a target-field testing vehicle that can be used for real environment testing in Phase III. Deliverables will include a prototype structural part, manufacturing cost analysis, weight saving estimates and technical reports and recommendations for transitioning the technology to operational systems.

PHASE III DUAL USE APPLICATIONS: Commercial Application – Potential avenues of early transition include the growing group of commercial firms exploring reusable space access vehicles. This new technology would reduce their launch system weights. Similarly, but in its early stages, commercial firms are also beginning to explore the business case for both supersonic and hypersonic commercial aircraft.

DOD/Military Applications - Weight on the back end of next generation fighter aircraft needs to be reduced for the aircraft to reach the range needed in the future. Increased thermal loads from thermally isolated engines can also lead to early structural failure (O&M issues) and weight issues. This technology would directly address both of these issue areas for these aircraft. Additionally, all hypersonic aircraft would directly benefit from increased range and/or payload resulting from weight reductions.

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3. Villace V. & Steelant J. (2015), ‘Thermal Paradox of Hypersonic Cruisers’, 20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference, 6-9 July 2015, Glasgow, Scotland, AIAA-2015.

KEYWORDS: Hypersonic flight, hot structures, thermal protection, thermal isolation

SB171-014 TITLE: Adaptive Control and Advanced Sensing for Turbine Based Combined Cycle Vehicles

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 17.1 DoD Program Solicitation and the DARPA 17.1 Phase I Instructions for Phase I requirements and proposal instructions.

TECHNOLOGY AREA(S): Air Platform, 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 5.4.c.(8) of the Announcement.

OBJECTIVE: Develop an adaptive control system for high-speed propulsion systems that leverages self-learning and distributed sensors on board and integrates them into the vehicle and propulsion systems.

DESCRIPTION: There is a critical DoD need for a robust turbine-based combined cycle (TBCC) propulsion-control scheme for hypersonic aircraft. One of the major challenges when operating a TBCC engine is obtaining stable mode transition while achieving the required performance and operability over the entire flight range. During this process, a successful propulsion control and actuation system must: (1) avoid inlet and/or engine unstart [1], (2) mitigate low-/high-speed inlet/engine interactions, (3) account for backpressure and moving-structure positioning effects, and (4) deliver optimal vehicle performance. [2]

Current sensors suffer from an inability to survive the hypersonic environment and provide reliable, distributed data such as pressure, temperature, heat flux, shear, displacement, flow velocity/Mach number, etc. Current sensors do not integrate well into hypersonic vehicle structures—whether they are high-strength metal alloys or hot ceramic structures—for a variety of reasons. Proper sensor selection and integration is vital to enabling an adaptive control system that can be successful over all vehicle operating modes.

The coupling among the aerodynamics, propulsion system, structure, controls, and thermal system presents a complex modeling and control problem that must be addressed before these combined-cycle vehicles can achieve regular operation.

PHASE I: Develop a preliminary adaptive control system architecture with integrated sensor requirements for a TBCC propulsion system. Study overall key control system performance drivers and derive the anticipated system performance metrics, and expose potential limitations of current state-of-the-art sensor systems as inputs to the control system. Conduct system-level modeling and analysis and show improvements in propulsion and overall vehicle performance. Phase I deliverables will include a final report that contains initial adaptive control system design and preliminary performance results.

PHASE II: Complete development of the adaptive control system and perform ground and/or flight testing of its control/sensing solution. Focus should be on validation of the control system to achieve smooth and stable mode transitions without inlet unstart and stable operation with high performance in both the low-speed and high-speed flowpaths. Phase II deliverables will include a final report that contains the finished adaptive control system design and demonstrations results.

PHASE III DUAL USE APPLICATIONS: An innovative adaptive control system may be an enabler of future supersonic and hypersonic commercial aircraft may enable the military to develop a reusable hypersonic aircraft for intelligence, surveillance, and reconnaissance (ISR).

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KEYWORDS: Turbine based combined cycle, TBCC, adaptive control, embedded sensors