DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)
12.2 Small Business Innovation Research (SBIR)
Proposal Submission 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 and STTR Programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.

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

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

Offerors responding to the DARPA topics listed in Section 8.0 of the DoD 12.2 SBIR Solicitation must follow all the instructions provided in the DoD Program Solicitation. Specific DARPA requirements in addition to or that deviate from the DoD Program Solicitation are provided below and reference the appropriate section of the DoD Solicitation.

SPECIFIC DARPA REQUIREMENTS:
Please note – these requirements and guidelines are supplemental to the DoD 12.2 SBIR Program Solicitation. For additional information, please refer to the corresponding section number in the DoD solicitation Preface).

2.3 Foreign National
DARPA topics are unclassified; however, the subject matter may be considered to be a "critical technology" and therefore subject to ITAR restrictions. ALL offerors proposing to use foreign nationals MUST follow Section 3.5, b, (8) of the DoD Program Solicitation and disclose this information regardless of whether the topic is subject to ITAR restrictions. See **Export Control** requirements below in Section 5.

3.5 Phase I Proposal Format

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 technical proposal for the Phase I Option counts toward the 25-page limit for the Phase I proposal.

A Phase I Cost Proposal ($150,000 maximum) must be submitted in detail online via the DoD SBIR/STTR submission system. Proposers that participate in this solicitation must complete the Phase I Cost Proposal, not to exceed the maximum dollar amount of $100,000, and a Phase I Option Cost Proposal, not to exceed the maximum dollar amount of $50,000.

Offerors are REQUIRED to use the online cost proposal for the Phase I and Phase I Option costs (available on the DoD SBIR/STTR submission site). Additional details and explanations regarding the cost proposal may be uploaded as an appendix to the technical proposal. The Cost Proposal (and supporting documentation) DOES NOT count toward the 25-page limit for the Phase I proposal. Phase I awards and options are subject to the availability of funds.

**Please note: 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.

3.7 Phase II Proposals

DARPA Program Managers may invite Phase I performers to submit a Phase II proposal based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3 of the DoD Program Solicitation. Phase II proposals will be evaluated in accordance with the evaluation criteria provided in section 4.3. Information regarding Phase II Proposal format will be included in the Phase II Invitation letter.

In addition, each Phase II proposal must contain a five-page commercialization strategy as part of the technical proposal, addressing the following questions:

1. Product Description/System Application – Identify the Commercial product(s) and/or DoD system(s) or system(s) under development or potential new systems that this technology will be/or has the potential to be integrated into.

**2. 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.

**3. 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.

4. Business Models/Procurement Mechanisms/Vehicles – Business models, procurement mechanisms, vehicles and, as relevant, commercial channels, and/or licensing/teaming agreements you plan to employ to sell into your targeted markets.

- What is the business model you plan to adopt to generate revenue from your innovation?
- Describe the procurement mechanisms, vehicles and channels you plan to employ to reach the targeted markets/customers.
- 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.

- What is the current size of the broad market you plan to enter and the "niche" market opportunity you are addressing?
- What are the growth trends for the market and the key trends in the industry that you are planning to target?
- What features of your technology will allow you to provide a compelling value proposition?
- 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.) 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
- as required, mature the manufacturing processes
- 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 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)?

The commercialization strategy must also include a schedule showing the quantitative commercialization results from the Phase II project that your company expects to report in its Company Commercialization Report Updates 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. - see section 5.4).

**Please note: 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.

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 or DoD Acquisition Program. The Phase II Option covers activities over a period of up to 24 months and should describe Phase II activities that may lead to the successful demonstration of a product or technology. The technical proposal for the Phase II Option counts toward the 40-page limit for the Phase II proposal.

A Phase II Cost Proposal ($1,000,000 maximum) must be submitted in detail online via the DoD SBIR/STTR submission system. Proposers that submit a Phase II proposal must complete the Phase II

Cost Proposal, not to exceed the maximum dollar amount of $1,000,000, and a Phase II Option Cost Proposal, not to exceed the maximum dollar amount of $750,000.

Offerors are REQUIRED to use the online cost proposal for the Phase II and Phase II Option costs (available on the DoD SBIR/STTR submission site). Additional details and explanations regarding the cost proposal may be uploaded as an appendix to the technical proposal. The Cost Proposal (and supporting documentation) DOES NOT count toward the 40-page limit for the Phase II proposal. Phase II awards and options are subject to the availability of funds.

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

4.0 Method of Selection and Evaluation Criteria

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

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

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

4.2 Evaluation Criteria

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

In Phase II, DARPA will select proposals for funding based on the evaluation criteria contained in Section 4.3 of the Program Solicitation in assessing and selecting for award those proposals offering the best value to the Government.

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

4.4 Assessing Commercial Potential of Proposals

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

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

4.5 SBIR Fast Track

Small businesses that participate in the Fast Track program do not require an invitation to submit a proposal, but must submit an application. The complete Fast Track application must be received by DARPA no later than the last day of the fifth month of the Phase I effort. Once your application is submitted, the DARPA Program Manager will make a determination on whether or not a technical proposal will be accepted for the Phase II effort. If the DARPA Program Manager approves the Fast Track application, the small business will have 30 days to submit the technical proposal.

Any Fast Track applications not meeting these dates may be declined. All Fast Track applications and required information must have a complete electronic submission. The DoD proposal submission site will lead you through the process for submitting your technical proposal and all of the sections electronically.

Firms who wish to submit a Fast Track Application to DARPA must utilize the DARPA Fast Track application template. Failure to follow these instructions may result in automatic rejection of your application. Phase I interim funding is not guaranteed. If awarded, it is expected that interim funding will generally not exceed $50,000. Selection and award of a Fast Track proposal is not mandated and DARPA retains the discretion not to select or fund any Fast Track applicants. NOTE: Phase I firms whose proposals are not accepted for a Fast Track Phase II award are not eligible to receive a Phase II invitation from the agency.

- DARPA encourages Phase I performers to discuss its intention to pursue Fast Track with the DARPA Program Manager prior to submitting a Fast Track application or proposal.
- Fast Track awards are subject to the availability of funds.
- After coordination with the DARPA Program Manager, the performer and the investor should submit a Fast Track application through the DoD Submission Web site no later than the last day of the fifth month of the Phase I effort.
- The Fast Track Interim amount is not to exceed $50,000.

- Additional information regarding the DARPA Fast Track process and application template may be found at: http://www.darpa.mil/Opportunities/SBIR_STTR/SBIR.aspx

4.6 Phase II Enhancement Policy

To encourage transition of SBIR projects into DoD systems, DARPA's Phase II Enhancement Program provides a Phase II performer up to $200,000 of additional Phase II SBIR funding if the performer can match the additional SBIR funds with funds from a DoD acquisition program, a non-SBIR/non-STTR government program or private sector investments. The Phase II Enhancement Program allows for an existing Phase II SBIR to be extended for up to one year per Phase II Enhancement application, to perform additional research and development and further mature the technology. Phase II Transition matching funds will be provided on a one-for-one basis up to a maximum amount of $200,000 of SBIR or funds in accordance with DARPA Phase II Enhancement policy.

Phase II Enhancement funding can only be applied to an active DoD Phase II SBIR contract. The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program may be obligated on the Phase II contract as a modification prior to or concurrent with the modification adding DARPA SBIR funds, OR may be obligated under a separate contract. Private sector funds must be from an "outside investor" which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

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

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

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

DARPA Phase I proposals **shall not exceed $100,000,** and are generally 6 months in duration.

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

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

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

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

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

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

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

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

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

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

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

5.11.s. Publication Approval (Public Release)
NSDD 189 established the national policy for controlling the flow of scientific, technical, and engineering information produced in federally funded fundamental research at colleges, universities, and laboratories. The directive defines fundamental research as follows: "Fundamental research' means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons."

It is DARPA's goal to eliminate pre-publication review and other restrictions on fundamental research except in those exceptional cases when it is in the best interest of national security. Please visit http://www.darpa.mil/NewsEvents/Public_Release_Center/Public_Release_Center.aspx for additional information and applicable publication approval procedures. Visit http://dtsn.darpa.mil/fundamentalresearch/ to verify whether or not your award has a pre-publication review requirement.

5.15.h. Human and/or Animal Use
This solicitation may contain topics that have been identified by the program manager as research involving Human and/or Animal Use. In accordance with DoD policy, human and/or animal subjects in

research conducted or supported by DARPA shall be protected. Although these protocols will most likely not be needed to carry out the Phase I, significant lead time is required to prepare the documentation and obtain approval in order to avoid delay of the Phase II award. Please visit http://www.darpa.mil/Opportunities/SBIR_STTR/SBIR.aspx to review the Human and Animal Use PowerPoint presentation(s) to understand what is required to comply with human and/or animal protocols.

- **Human Use:** All research involving human subjects, to include use of human biological specimens and human data, selected for funding must comply with the federal regulations for human subject protection. Further, research involving human subjects that is conducted or supported by the DoD must comply with 32 CFR 219, *Protection of Human Subjects* http://www.access.gpo.gov/nara/cfr/waisidx_07/32cfr219_07.html) and DoD Directive 3216.02, *Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research* (http://www.dtic.mil/whs/directives/corres/pdf/321602p.pdf).

  Institutions awarded funding for research involving human subjects must provide documentation of a current Assurance of Compliance with Federal regulations for human subject protection, for example a Department of Health and Human Services, Office of Human Research Protection Federal Wide Assurance (http://www.hhs.gov/ohrp). All institutions engaged in human subject research, to include subcontractors, must also have a valid Assurance. In addition, personnel involved in human subjects research must provide documentation of completing appropriate training for the protection of human subjects.

  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.

  The amount of time required to complete the IRB review/approval process may vary depending on the complexity of the research and/or the level of risk to study participants. Ample time should be allotted to complete the approval process. The IRB approval process can last between one to three months, followed by a DoD review that could last between three to six months. No DoD/DARPA funding can be used towards human subjects research until ALL approvals are granted.

- **Animal Use:** Any Recipient performing research, experimentation, or testing involving the use of animals shall comply with the rules on animal acquisition, transport, care, handling, and use in: (i) 9 CFR parts 1-4, Department of Agriculture rules that implement

the Laboratory Animal Welfare Act of 1966, as amended, (7 U.S.C. 2131-2159); (ii) the guidelines described in National Institutes of Health Publication No. 86-23, "Guide for the Care and Use of Laboratory Animals"; (iii) DoD Directive 3216.01, "Use of Laboratory Animals in DoD Program."

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: https://mrmc-www.army.mil/index.cfm?pageid=Research_Protections.acuro&rn=1.

6.3 Notification of Proposal Receipt

After the solicitation closing date, DARPA will send an e-mail to the person listed as the "Corporate Official" on the Proposal Coversheet with instructions for retrieving the letter acknowledging receipt of proposal from the DARPA SBIR/STTR Information Portal.

6.4 Information on Proposal Status

Once the source selection is complete, DARPA will send an email to the person listed as the "Corporate Official" on the Proposal Coversheet with instructions for retrieving letters of selection or non-selection from the DARPA SBIR/STTR Information Portal.

6.5 Debriefing of Unsuccessful Offerors

DARPA will provide debriefings to offerors in accordance with FAR Subpart 15.5. The notification letter referenced above in paragraph 6.4 will provide instructions for requesting a proposal debriefing. Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced. All communication from the DARPA SBIR/STTR Program management will originate from the sbir@darpa.mil e-mail address. Please white-list this address in your company's spam filters to ensure timely receipt of communications from our office.

DARPA SBIR 12.2 Topic Index

SB122-001 TITLE: Controlling Antibiotic Resistant or Highly Virulent Pathogens Through Plasmid Curing

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Develop a novel plasmid curing therapeutic capable of displacing antibiotic resistance and/or virulence causing plasmids from bacteria. Therapeutic interventions are sought that will be efficacious against a range of human pathogens of interest to the DoD.

DESCRIPTION: The combined threat of the increasing prevalence of drug-resistant bacteria and a diminishing antibiotic pipeline places our warfighters at risk not only from health care associated and community acquired infections, but also from pandemics, emerging infectious pathogens and the intentional use of resistant pathogens for bioterrorism.

One of the major routes by which bacterial pathogens become resistant to antibiotics and more virulent is through Horizontal Gene Transfer (HGT), which allows for genetic material transfer in the form of extrachromosomal plasmids from one cell to another. This phenomenon is capable of transferring resistance and/or virulence genes to normally antibiotic susceptible and avirulent bacteria. This creates a severe risk to front line antibiotic treatments, illustrated by the recent occurrence of isolates from methicillin-resistant Staphylococcus aureus (MRSA) that contain vancomycin resistance genes (in plasmid form) transferred from vancomycin-resistant enterococci (VRE). Likewise, G9241, a benign form of Bacillus cerus has acquired a B. anthracis virulence plasmid, demonstrating transfer of virulence plasmids by HGT.

One way to reverse the resistance of emerging or engineered bacteria created by HGT may be to specifically target the plasmids being transferred between the cells, rather than using methods to directly kill the cells. This idea is known as Plasmid Curing. Proposals are sought that will develop novel plasmid curing therapeutics against plasmid encoded antibiotic resistant and highly virulent pathogens. Studies working with ESKAPE bacteria (Enterococcus, Staphylococcus, Klebsiella, Acinetobacter, Pseudomonas, and bacteria that produce Extended Spectrum Beta Lactamase (ESBL) enzymes (Enterobacter and Escherichia coli)) are encouraged. The therapeutic should be clinically relevant and therefore shown to be non-toxic to humans and appropriate regulatory approval that would be needed in bringing forth such a therapeutic in the drug development pipeline should be considered. Developing such a safe intervention may help protect and provide appropriate treatment to our warfighters against the dangerous pathogens they encounter in theatre.

PHASE I: Demonstrate via in vitro experiments that the proposed therapeutic is capable of removing any stable plasmid from a bacterial model (identified by proposer). Therapeutic approaches that are effective against both Gram (+) and Gram (–) will be prioritized. Metrics should demonstrate clearance and include clearance from two separate bacteria. If only partial clearance is achieved, state how this is still appropriate as therapeutic treatment. Propose an infectious in vivo animal model capable of assessing the health of the microbiome after treatment in addition to the efficacy of the treatment. Criteria also include providing details of the therapeutic; delivery method, proposed dosage, storage and stability, etc. Please note: Animal Subject Research (ASR) and Human Subject Research (HSR) are NOT expected or required for Phase I.

PHASE II: Demonstrate the efficacy of the therapeutic to cure two plasmid containing pathogens of interest (identified by the proposer and relevant to the warfighter) that are either antibiotic resistant or virulent in an in vivo animal model. Demonstrate further the ability of the therapeutic to remove two or more plasmids from a pathogenic bacteria within the same animal model. Therapeutic approaches that are effective against both Gram (+) and Gram (–) will be prioritized. Appropriate toxicology studies of the therapeutic in an animal model to support an IND application should also be conducted. The overall health of the microbiome after use of the therapeutic in vivo should be described. Make sure to adhere to biosafety and ethical guidelines.

PHASE III: Successful or promising approaches identified in Phase II would continue the development pathways for FDA approval and would support protecting the warfighter against such microbial threats. In addition, these

therapeutics can be used as a medical countermeasure against any pathogen that may strike the general population. Phase III and IND approval would lead to appropriate clinical trials to gain FDA approval that may be funded through additional government and/or private funding sources.

This SBIR Topic addresses the biomedical key technology area identified in the Defense Technology Area Plan from February 2003. Specifically drug resistant microbes are a significant current and future threat to US military personnel deployed overseas. Military personnel suffer significant life and limb threatening injuries and survive or resuscitated only to face months of hospitalization and multiple surgeries trying to combat extensively antibiotic resistant microbial pathogens. In the current military medical system we encounter microbes that are not responsive to any known antibiotics. In addition, naturally emergent or purposely engineered extensively antibiotic resistant microbes pose a significant threat to military operational activities. Most antibiotic resistance and many virulence genes are carried on portable and easily transferable circles of DNA called plasmids that live inside bacteria. Research and development under our topic will identify innovative ways of "curing" plasmids, that is, to directly attack the plasmids instead of the bacteria. Although high risk, if successful this approach could open a new way of countering biological threats.

REFERENCES:
1. Int J Antimicrob Agents. 2008 Nov;32(5):405-10. Epub 2008 Aug 20.

2. Curr Opin Chem Biol. 2008 Aug;12(4):389-99. Epub 2008 Jul 14.

3. Indian J Med Res. 2010 Jul;132:94-9.

4. Biotechniques. 2010 Mar;48(3):223-8.

5. Infect Immun. 2011 Aug;79(8):3012-9. Epub 2011 May 16.

KEYWORDS: Resistance, bacteria, plasmid, Acinetobacter, antibiotic, horizontal gene transfer, virulence, ESKAPE

SB122-002 TITLE: High-resolution, Ultra-sensitive Magnetic Imaging Using an Ensemble of Nitrogen-Vacancy (NV) Centers in Diamond

TECHNOLOGY AREAS: Materials/Processes, Biomedical

OBJECTIVE: Develop compact magnetic field imagers with nT/Hz^1/2 field sensitivity and sub-micron spatial resolution using an optically-addressed ensemble of NV centers in diamond.

DESCRIPTION: Highly sensitive magnetic field imaging systems are important tools in both military and civil sectors, finding applications ranging from the detection of landmines and submarines to the high-resolution imaging of sub-cellular phenomena. State-of-the-art high-resolution magnetometers, Superconducting Quantum Interference Devices (SQuIDs), are frequently found in medical devices for magnetoencephalography (MEG) and magnetic resonance imaging (MRI). They can operate at the nT/Hz^1/2 level but are limited to micron resolution, require cryogenic environments, and consume high power.

An attractive means of boosting the sensitivity and resolution of modern magnetometers in a room temperature, low power and rugged device, is to employ optically-addressed ensembles of NV centers in diamond. As well as supplanting SQUIDS in medical applications, such magnetometers, with sub-micron spatial resolution, could be used in the non-destructive imaging of integrated circuits for the presence of malicious circuits. NV centers are atom-like defects in diamond that are highly sensitive to magnetic fields despite being embedded in the solid state. In fact, operation at the pT/Hz^1/2 level has been demonstrated and it is expected that nm-scale resolution can be achieved [1-4].

This approach is particularly exciting for biological and neuroscience applications because it works under ambient conditions (room temperature and pressure) without significantly affecting the operation. Furthermore, ensemble

NV magnetometry offers a large field-of-view, a robust, solid state system and low noise optical preparation and detection. Because sensitivity scales as the square root of the number of NV centers [5], ensembles are essential to achieving high-sensitivity over a broad area.

While impressive results have been obtained in the laboratory, significant development is necessary to construct a robust packaged imaging system with high-NV density and sufficiently narrow inhomogeneous broadening, reduced background noise and efficient collection efficiency. Methods of achieving the critical properties of a magnetic imager could include, but are not limited to, an improved collection efficiency with solid-immersion lenses [6], side collection schemes or anti-reflection coatings; reduced background noise with IR absorption spectroscopy [2] in a low finesse resonant cavity or obtaining high resolution with STED spectroscopy [7].

PHASE I: Design a robust packaged magnetic field imaging system with an ensemble of NV centers in diamond. Such a system should include high-grade diamond with NV ensembles with long coherence times, a novel imaging system with high-resolution, and optimized NV collection efficiency over a broad area. The chosen work must be compatible with an imaging system that has 1-10 nT/Hz^1/2 ac sensitivity and a 10-100 nm spatial resolution. Exhibit the feasibility of the approach through a laboratory demonstration. Phase I deliverables will include a design review including expected device performance and a report presenting the plans for Phase II. Experimental data demonstrating feasibility of the proposed device is favorable.

PHASE II: Fabricate and test a prototype device demonstrating the device performance outlined in Phase I. The Transition Readiness Level to be reached is 5: Component and/or bread-board validation in relevant environment.

PHASE III:Compact magnetic field imagers at the submicron level could have applications in the non-destructive imaging of integrated circuits for the presence of malicious circuits and neuronal and brain imaging. Operation at room temperature may lead to numerous applications in the imaging of living tissue such as imaging the structure and composition of proteins and molecules possibly in real time, informing the development of pharmaceuticals. Innovations in Phases I and II will enable such devices to transition out of the laboratory and into fieldable devices.

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KEYWORDS: Magnetometry, NV center, diamond, ensembles, lasers

SB122-003 TITLE: Minimally Invasive, Self-Collection of Large Volume Biospecimens

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop advanced technologies that can be self-operated by a patient or a minimally trained operator to collect large volumes/weights of a biospecimen for clinical use, such as diagnostic and remote clinical trials, or for research applications such as biomarker discovery/validation.

The majority of diagnostic tests and research assays require blood biospecimens that are traditionally collected using phlebotomy techniques performed by trained personnel. In limited resource areas, such as DoD deployment locations, remote or impoverished geographic areas, or emergency response locations, absence of blood sample collection by a trained phlebotomist can be a significant limitation to clinical care. Lancet or finger stick blood collection methods are one solution to minimize the need for these resources but suffer from low biofluid volumes that statistically may not contain the biomarker(s) of interest at the concentrations necessary for detection or clinical correlation. See reference #1 for examples of proteins in blood. Solutions are sought that enable the simple self-collection of sufficient biospecimen volumes or weights for the detection of low abundance diagnostic biomarkers. All biospecimens are of interest and include blood, sweat, tears, etc. Technologies developed should be minimally invasive, simple to operate, and allow for remote self-collection of a sufficient sample volume (e.g. >100 microliters for blood) or weight, to allow for detection of a low-abundance panel of biomarkers at a reference laboratory or point-of-care setting. Potential users include minimally trained individuals and medics in settings where phlebotomy is not available.

If the technology is successfully developed, the capability to statistically capture low abundance biomarkers by increasing the amount of biospecimen collected in low resourced settings is anticipated to widely improve clinical care and biomedical research by enabling remote clinical trials, distributed remote access diagnostics, public health surveillance and biomarker research.

DESCRIPTION: There is the need for technologies capable of collecting patient biospecimens at sufficient volumes or weights, in a manner that allows for statistically relevant clinical guidance after the sample has been processed and analyzed. At the same time, enabling the capability to self-collect a biospecimen could provide a means to more confidently diagnose or track disease at its earliest stages, provide an ability to better expand clinical trials into remote settings, and increase the diversity of population cohorts needed for biomarker research. For example, blood biospecimens are the biofluid of choice for most diagnostic applications but require trained phlebotomists to collect and process. Simultaneously, there has been a push towards the miniaturization of detection technologies (eg. “lab-on-a-chip” and “nano-bio” technologies), but there has been a disconnect between sample acquisition and downstream analysis in a manner that allows for the detection of low abundance analytes.

Aggressive low volume scaling through finger-stick or lancet components affords clear advantages for sample preparation, reagent usage, thermal load, manipulation, and reaction kinetics, but there is nevertheless the challenge of dealing with “the law of small numbers”, or Poisson’s Distribution, which indicates that for small biospecimen volumes there may be no targets available for amplification or detection. In other words, diagnostic instruments may be developed that are small, portable, and require only a few drops of blood, but if the target analyte is not present in the small volume, the test could be susceptible to false negatives or not provide sufficient statistical confidence to provide clinical guidance.

Additionally, biospecimens other than blood, such as sweat, interstitial fluids, or tears may have the potential to be a powerful natural repository of clinically relevant biomarkers but there lack the technologies for self-collection and concentration. Technologies that offer the simplicity of a finger stick device (as an example) with the capability to collect larger biospecimen volumes or weights would overcome a diagnostic hurdle that limits widespread diagnostic testing outside of traditional clinical settings such as a clinic or hospital. Therefore, proposals are sought that address large volume (eg. >100 microlitersfor blood) or weight biospecimen collection via a device that is simple to operate and minimally invasive. The design should consider minimally trained individuals and medics as potential users. Proposers are encouraged to consider methods and technologies compatible with clinical workflows, good laboratory practices (GLP), and good manufacturing practice (GMP) procedures.

PHASE I: Demonstrate feasibility of methods or technologies for large volume or weight collection. Proposers must address both the volume/weight of biospecimen collected, as well as address how device operation is conducted under conditions of minimal invasiveness and ease-of-use. Proposers should aim to collect as large a volume or weight as possible (eg. at least 100 microliters for blood) while retaining the capability for operation by a minimally trained user.

Collection devices may be designed to hold the collected biospecimen within the device or to dispense the biospecimen into an instrument or alternate storage device. Proposers should demonstrate initial designs and collection volumes/weights, and project Phase II collection volume/weight capabilities.

Proposals that demonstrate universal compatibility for downstream analysis under a wide dynamic range of analytes are preferred. Of interest are quantitative metrics measured with a variety of protein, nucleic acid, metabolic and/or other analytes relevant to human biology. Phase I efforts should justify the applicability to settings such as home use, and consideration of FDA regulations is encouraged.

PHASE II: Phase II efforts should quantify collected biospecimen volume/weight and address reproducibility of the collection volume/weight with different prototypes under similar and different conditions. Detection of a panel of well-characterized, low abundance biomarkers should be demonstrated from collected samples using standard laboratory practices. Of interest are quantitative metrics measured with a variety of protein, nucleic acid, metabolite and/or other analytes relevant to human biology.

Phase II efforts should evaluate the device effectiveness and reproducibility when operated by untrained users. Additional interests include demonstrations that the proposed technology is developed to include standardization/normalization of the biospecimen to reference analyte concentrations across collections, with sensitivities that can address sample variability.

Manufacturing designs and costs should be considered for all components of the device. Compatibility of the collection device with downstream biospecimen storage devices and/or analysis technologies should be considered. Device potential for FDA clearance as a blood collection device for home use or physician office settings should be described.

PHASE III: The technology to be developed should enable blood collection outside of a major clinical facility and therefore could have significant impact on the clinical diagnostic market. There is a significant commercial market for medical diagnostics and home-use physician-office based diagnostic testing is a growing element of this market. The developed technology would potentially allow collection of sufficient sample in such settings, as well as enable clinically valid diagnostic testing and biomarker research. Potential commercial partnerships/customers include major diagnostics companies and life sciences research technology companies.

The technology to be developed is critical for DoD, as many medics have minimal training. Development of a FDA-approved collection device could enable use of newly developed diagnostic tests in remote/deployment settings as well as expand the military capabilities to perform more effective clinical trials of new therapeutics and diagnostics in remote settings or expand capabilities to detect and track emerging disease. Potential transition customers include Center for Disease Control and Prevention, Air Force Surgeon General, Military Health System - Defense Medical Research and Development Program (MHS DMRDP), Military Infectious Diseases Research Program (MIDRP), and the commercial sector.

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KEYWORDS: biospecimen collection, diagnostics, self-collection, self-sampling, remote access, clinical trials, biomedical research, biomarkers

SB122-004 TITLE: Blending Skills Training and STEM Education: Game-Based First-Responder Application

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a mobile application that uses innovative game-based strategies and visualization techniques to teach medical first-responder skills combined with intelligent tutoring systems to teach underlying STEM principles. Game design, architecture, and research approach should allow for the optimization of pedagogical approaches based on performance of the individual learner and across a large population of users.

DESCRIPTION: Computer-based medical training applications are usually developed to mimic skill sets that would normally require a live patient or manikin rather than considering what a computer provides that these methods do not. Thus, medical simulations have focused heavily on training specific skills and techniques as a surrogate to other modes of training. However, computer game-based technologies provide the opportunity to combine skills training with generalizeable educational principles. For example, instead of simply providing instruction on where to apply a tourniquet, a computer-based system can reinforce the lesson with demonstrations and discussion of the underlying physiology of the circulatory system. Thus, a student may learn why wounds in slightly different locations respond differently or why applying pressure in certain conditions is essential. The game-based approach also allows for integrating the lessons into dramatic and engaging scenarios.

Combining skills training with the underlying STEM principles from biology/physiology should more readily allow for the generalization of the skills to novel situations. This tool is envisioned for both medical training and in basic civilian education science classes. The goal is to create a game-based application on mobile platforms to teach first responder principles that integrates intelligent tutoring systems to not only teach basic skills, but answer the underlying questions of why a student should or should not have responded the way they did. Using this application, students should learn BOTH basic skills and also basic principles of human physiology. Thus, this can be used as a classroom resource for science education as well as a resource to teach medical skills for first responders.

The underlying architecture should allow for the analysis and optimization of the software to both the individual user and across the entire population of users. We are not seeking standard computer-based learning systems, but game-based interactive systems that are engaging and challenging to the user. Design and development should be to professional game standards and the proposed game concepts should be compelling, innovative, and designed to motivate users for continued interactions. Innovative approaches for visualization and interaction with these different types of information are required.

The system should educate, train, and assess the student's knowledge. The patient models should respond accurately and be based on underlying physiology models that respond appropriately to both injury and treatment. The simulation should include a case editing tool that instructors and students can use to customize injury scenarios. The system should be developed in such a way to allow customization of options for basic first responders with limited resources to more advanced options for Corpsmen/Medics/EMTs.

Proposals must reflect team expertise in medical training (military and civilian), education, and game production. Teams that do not reflect a balance between these skill sets will not be considered. Proposals should clearly outline

proposed development tools, design standards, educational approaches, and validation strategies. Proposals must also discuss details of transition strategy and market opportunities.

PHASE I: Identify the exact training/education goals of the prototype system and metrics for success. Develop the conceptual design and framework for the proposed system. At a minimum, provide extensive storyboards outlining gameplay, user interface, and user interactions. Develop detailed strategies for using this application for medical training and in the classroom. In preparation for Phase II, develop a robust methodology with clear metrics for assessing usability, user acceptance, and effectiveness of the application. It is important to note that there will be no human use testing in Phase I.

PHASE II: Develop, demonstrate, and validate an initial prototype on mobile-based software platforms that can be used in a variety of educational/military environments. The required deliverable for Phase II will include: the prototype system, demonstration and testing of the prototype system, and a Final Report. The Final Report will include (1) a detailed design of the prototype mobile, game-based application(s) tool sets, (2) the experimental results from such toolsets, and (3) a plan for Phase III.

PHASE III: Delivery of a complete game-based mobile application with validated pedagogical efficacy that is engaging and ready for integration into identified learning environments. Scenarios should be applicable to civilian first-responder training. Application should be available for licensing or download.

Delivery of a complete game-based mobile application (IOS/Android) with validated pedagogical efficacy that is engaging and ready for integration into identified learning environments. Scenarios should be applicable to first-responder scenarios encountered by military personnel.

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KEYWORDS: Medical training and simulation, intelligent tutors, education, pedagogy, gameplay, video games, mobile device, IOS, ANDROID, medics, corpsmen

SB122-005 TITLE: Innovative Passivation to Increase the Power at Which Laser Diode Fails

TECHNOLOGY AREAS: Air Platform, Materials/Processes, 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Improve the reliability/lifetime and increase power and performance of high power laser diodes (LD).

DESCRIPTION: There is a compelling need for substantially increasing the power and brightness of LD optical-pumps in the 9xx nm spectral range for scaling single-mode narrow-line fiber lasers to high power for DoD high energy laser (HEL) applications. The power and brightness of state-of-the-art LDs are severely limited by catastrophic optical-damage (COD) at the front facet. COD severely limits the power/bar that could be attained and hence a larger number of LD bars are required for a given LD pump power. The larger number of bars increases system complexity and decreases efficiency of the high power laser system. In addition it results in an increase in size, weight and cost of the laser system.

The focus of this SBIR is to significantly improve the reliability of high-power semiconductor LDs so they can be reliably operated at 6-7X higher power density per bar than the present state-of-the-art. Specifically, state-of-the-art 980nm, 20 percent fill-factor, 10mm wide bars operate at approximately 70W. Achieving this goal of 400-500W/bar may impact DARPA's high-power fiber lasers such as Revolution in Fiber Lasers RIFL by increasing the specific power of laser diodes pumps from the present 1kW/kg to 6-7kW/kg. Since LD pumps contribute about 50% of the cost and weight of the high power laser system, increasing the specific power (kW/kg) will have a significant impact on the size of the high energy laser system. In addition, the cost of the laser diode pumps is inversely proportional to the power/bar and increase of 6-7x in power that could be obtained from a bar decreases the cost by a similar factor.

The weight and cost of LD pumps is estimated to be approximately 50% of the laser system so decreasing them by 6X will decrease the all-important weight and cost of the HEL by 40%. This technology may also provide similar benefits to the HEL solid-state lasers.

PHASE I: Determine the technical feasibility of the growth of a single-crystal passivation layer on the (110) facet of a 9xx laser diode formed at low temperature and in ultra-high vacuum. Current passivation techniques are either amorphous, resulting in significant residual surface state density within the bandgap, or require high temperature growth which degrades the Ohmic contacts. Low temperature growth (<= 400°C) is therefore required to ensure compatibility with existing laser diode processing and ultra-high vacuum (< 1e-9 Torr) is required to prevent oxidation of the cleaved surface. The passivation layer should fully passivate the facet and prevent the defects. It should also prevent absorption of the laser line. Phase I deliverables will include a demonstration of lattice matched high band-gap crystal growth on the cleaved end of the GaAs laser diode.

PHASE II: Develop, demonstrate and validate reliable operation (500hr) at 500W of a 10mm-wide, 980nm laser-diode bar with fill-factor =20% with innovative passivation demonstrated in Phase I.

PHASE III: High-power LDs have a large $3 billion market that is growing at 20 percent annually. The technology developed in this SBIR may be a valuable asset for this market as it should significantly decrease the all-important cost or dollars/watt by 6X.

The passivation technology developed under this SBIR may have an impact on DoD HEL systems that use LD pumps.

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KEYWORDS: High-power, high brightness laser diodes, high energy lasers, facet passivation

SB122-006 TITLE: Ultra-Bright Diode Laser Emitters for Pumping High-Power Fiber Amplifiers

TECHNOLOGY AREAS: Materials/Processes, 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Demonstrate a wavelength-stabilized diode laser system for pumping high-power fiber laser amplifiers consisting of diode laser emitters that are at least ten times brighter than conventional broad-stripe emitters.

DESCRIPTION: High average and peak power fiber lasers and amplifiers offer an attractive combination of high efficiency, near diffraction-limited beam quality, low phase noise, and reliable operation. They have found wide use in industrial and scientific applications ranging from cutting and welding to gravitational wave detection, and their small size makes them promising candidates for defense applications such as laser-based weapons and long-range lidar on airborne platforms. Fiber laser and amplifier systems can also be scaled to even higher power using coherent or spectral beam combining [1], but two competing nonlinear processes limit the power available from a single continuous-wave fiber amplifier and, by extension, the power from a beam-combined system.

To achieve good efficiency, both coherent and spectral beam combining require the fiber lasers and amplifiers to have a narrow spectral bandwidth, but these narrow-band systems are very susceptible at high powers to stimulated Brillouin scattering (SBS), which is a nonlinear process that can scatter significant power backwards into the laser system. Several approaches have been used to suppress SBS, but the most common is to utilize short fibers with large cores to reduce the interaction length and lower the Brillouin gain [2].

Recently, a new modal instability has been identified that drastically reduces the output beam quality and limits the useful power from high-power beam-combinable amplifiers [3]. Experimental data show that a significant amount of signal power is coupled into higher-order optical modes of the fiber core and/or cladding when the average amplifier power exceeds a threshold on the order of 1 kW. Theoretical investigations into the mode-coupling mechanism and ways to mitigate it are not yet conclusive [4]. Smaller cores with fewer modes would reduce this instability but at the expense of higher Brillouin gain.

One approach to reducing both SBS and modal instabilities is to use extremely short fibers with narrow cores that guide only a few modes, at most. However, short double-clad fibers require extremely bright pump lasers that are spectrally narrowed and locked to match the gain fiber’s absorption peak in order to efficiently absorb the pump light. Currently, state-of-the-art fiber-coupled diode pump lasers are limited to an ex-fiber brightness of ~25 MW/cm2sr, corresponding to 100 W from a fiber with a 105-µm core and 0.12 NA (numerical aperture) without wavelength stabilization [5], but this fiber-coupled spatial brightness is significantly lower than the record of 1 GW/cm2sr for a single diode laser [6,7].

This SBIR topic seeks innovative approaches to realizing a high-power wavelength-stabilized fiber-coupled diode laser system that employs extremely bright emitters to achieve an ex-fiber brightness >100 MW/cm2sr. The resulting pump laser module could be transitioned to multiple government-funded high-power laser programs or commercialized as a part of systems targeting industrial laser cutting applications.

PHASE I: Demonstrate a single diode laser operating at ~976 nm with output power >10 W, spatial brightness >1 GW/cm2sr, and electrical-to-optical efficiency >52%. All three performance metrics should be achieved simultaneously on a single device. Develop a concept to package several of these emitters into a single wavelength-stabilized module that can achieve the Phase II performance metrics.

PHASE II: Construct and demonstrate a prototype laser system suitable for pumping high-power fiber lasers based on the Phase I module concept and diode emitters. The key performance goals are: 1) fiber-coupled power >500 W continuous-wave, 2) ex-fiber spatial brightness >100 MW/cm2sr, 3) >42% ex-fiber electrical-to-optical efficiency, 4) <0.25 nm full-width half-maximum output spectrum*, 5) $\Delta\lambda/\Delta T < 0.07$ nm/°C, 6) $\Delta\lambda/\Delta P < 0.03$ nm/W, and 7) specific weight <1 kg/kW of fiber pump power delivered. Conduct a preliminary reliability assessment. The final Phase II system should be at Technology Readiness Level 6.

*The narrow spectral width is to allow the future potential for spectral beam combining to even higher spatial brightness within the narrow absorption peak of Yb-doped silica (~7 nm bandwidth).

PHASE III: Industrial applications include metal cutting, welding, and marking. A laser module meeting the Phase II metrics would have sufficient power and brightness for entry-level cutting applications, and several Phase II modules could be spectrally combined into a single kW-class fiber-coupled cutting system. Direct-diode lasers are of significant industrial interest because of their potential for higher reliability, better efficiency, and lower complexity than competing solid-state and fiber lasers [8].

Military applications include lidar and directed-energy weapons, and the Phase II technology could be potentially transitioned to multiple government directed-energy programs, including ongoing high-power fiber laser programs funded by DARPA and HEL-JTO, such as Excalibur.

Once delivered, a fiber-coupled Phase II module could be readily spliced into an existing high-power fiber amplifier system, and new laser systems could be designed to exploit the brightness of these pump lasers. Since light-weight packaging would be developed during Phase II, Phase III development activities might include increasing output power, improving efficiency, and/or modifying the module for alternative thermal management techniques (e.g. phase change materials or spray cooling).

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

SB122-007 TITLE: Foliage Propagation Model Development to Support New Communications Concepts

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Develop detailed foliage propagation models applicable to multiple environments that will support creation and analysis of new communications concepts that greatly exceed the operational performance of current systems in these environments.

DESCRIPTION: The need for propagation models that extend beyond free space and urban environments into foliage-rich environments is well-known. The rising need for communications in forests, jungles and triple canopy environments shows the importance of characterizing these RF environments. This will allow for real-time situational awareness, sensor and command and control data throughout the entire battle space. Traditional communications through dense foliage and vegetations is challenged by severe multipath and attenuation thereby limiting the warfighter's access to critical data. There is little to no data on RF propagation across the entire frequency spectrum through the various foliage elements and current models, such as FOREST, typically view foliage environments as a uniform dielecteric slab and are limited by the assumptions that they treat forests as reasonably uniform, the floor as absorptive, and only address frequencies up to approximately 1 GHz. A model is needed that can address the entire range of spectum, including current military radio systems, new 4G wireless technologies, millimeter wave communications (30-300 GHz), and can be equally applied to forest and jungles that are assumed to be non-uniform. A more thorough understanding of how RF signals act in these areas will allow for a communications concept to be developed that will overcome these challenges and limitations. The model will be combinable with other RF models to create a single, comprehensive RF propagation model.

PHASE I: Perform a study on RF propagation through various types of foliage and provide the framework for a comprehensive foliage propagation model. The study should analyze the effects of multipath, attenuation and dispersion and be capable of statistical characterizations of system performance. It should analyze current limited models to decide if these models can be leveraged to support the new model and investigate other technologies that may provide indirect information that could be utilized or adapted such as information from LandSat imagery or foliage penetrating radars. This analysis will include RF properties from multiple types of foliage, trees and vegetation to provide a basis for the study. Phase I should result in the framework for a comprehensive foliage propagation model in Phase II.

PHASE II: Develop a comprehensive foliage model to accurately predict RF propagation through multiple types and densities of vegetation. The model will be validated and tested using government provided emperical data as well as real-world measurements obtained from field testing in various enviornments across the full spectrum of frequencies. The model will then be used to support a separate research and development program of new communications technologies and systems with performance capabilities beyond current systems operating within these environments, e.g. increased communications range, accuracy, capacity, bandwidth and reduced equipment size, weight and power. Phase II will result in a comprehensive, working foliage penetration model that can be applied to current and future communications systems in these type environments. The technology readiness level at the end of this phase will be a minimum Level 6.

PHASE III: The system should be applicable to commercial and homeland security operations in dense, foliage-rich environments. A military prototype communications system, based on the results found from the Phase II foliage propagation model, should be designed, field tested and verified. Potential interested military organizations include the Defense Spectrum Organization (DSO) and CERDEC's Space & Terrestrial Communications Directorate, specifically the Antennas & Spectrum Analysis Division.

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KEYWORDS: Jungle, Forest, Dismount, Sensors, Communications, RF Propagation

SB122-008 TITLE: High Amperage Large-scale Electrical Energy Storage

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Demonstrate megawatt (MW) scale electrical energy storage at high charge and discharge rates, high cycle life, and high energy density.

DESCRIPTION: Electrical power is transient in nature and effective storage of megawatt scale power is a critical technology to enable forward operating base (FOB) level power management. Currently available batteries are not effective solutions with inadequate large scale energy storage, rapid recharge/discharge capabilities, and cycle life. These deficiencies preclude their use for vehicle portable large scale storage and limit the utility of renewable power sources which are subject to large fluctuations. An effective solution has the potential to impact a variety of applications, such as load leveling of power grids to providing uninterruptible backup power, and reduce the logistical burden associated with fuel for power generation at critical DoD bases and FOBs. In addition, large scale power storage technology will enable the use of renewable power generation including photovoltaics or wind power. This SBIR topic seeks new high-performance energy storage solutions that will reduce fuel dependence for power generation at FOBs.

PHASE I: Prepare a feasibility study of an energy storage concept. Proof of concept demonstration with the following system level properties: lifetime >1,000 cycles, >100 Wh/kg, >0.3 kWh/l, > 1 MW charge and discharge rates, and storage efficiency over 24 hours >90%. The technology should have a path to: lifetime >5,000 cycles, >150 Wh/kg, >0.5 kWh/l, >1.5 MW charge rate, and storage efficiency over 95%. As part of the final report, plans for Phase II will be proposed.

PHASE II: Finalize the Phase I design and deliver two 150 kWh prototype systems for government evaluation. Target Transition Readiness Level at the end of Phase II: 4.

PHASE III: High performance MW scale energy storage systems have both military and commercial dual use applications for uninterruptable power systems, for power grid load leveling, and for energy storage from renewable power generation systems.

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KEYWORDS: Energy storage, high amperage, high cycle life, high charge/discharge rates, high energy density

SB122-009 TITLE: Human-centric Coalition Space Situational Awareness

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Demonstrate a cognitive-centric User-Defined Operational Picture (UDOP) capability that allows multi-national teams to maintain a common understanding of the space situation.

DESCRIPTION: This effort will apply cognitive science technology to develop human-system interfaces for a multi-national space operations center with a focus on Intelligence, Surveillance and Reconnaissance (ISR). This area is critical to space situational awareness (SSA) and a focus area for the Air Force, DARPA, and overall national security.

The U.S.-centric Joint Space Operations Center (JSpOC) is quickly becoming a multi-national Coalition Space Operations Center (CSpOC). These multinational forces do not always have access to the same information and yet they need a common situational understanding to make informed joint decisions. Differences in cultures, security levels, collaboration preferences, tactical priorities, and information accessibility pose unique cognitive science challenges for human-system interface design. Applying innovative cognitive science solutions to the problem – such as work-centered/sensemaking support and visual analytics – could positively impact routine operations and dramatically impact operations during contingencies when human-to-human coordination needs to happen quickly.

Effective coordination among multi-national forces requires continuous and rapid information sharing, group problem solving, error-checking, and progress monitoring. All of these and possibly other capabilities are needed to support independent and interdependent tasks for plans, operations, intelligence, and communication. These team members will need a decision-centric environment supporting work flows and processes. Additionally, team members separated by security levels and/or geography will need an extension of the UDOP concept for their collaborative work environment where they can generate shared understanding and synchronize collective Command and Control (C2) and ISR activities and missions.

Innovative technology is needed to identify and navigate multi-national teams through relevant human-centric issues allowing effective, accurate, and timely collaboration and information sharing. This tool will provide the underpinnings of multi-national force collaboration strategies allowing teams the ability to provide C2 information to Allied Force commanders. A few issues of concern might be: (1) human-computer interface differences, (2) multi-level security, (3) cultural differences, (4) language and terminology, (5) working and learning environment differences and preferences, and (6) command structure differences and preferences.

Ultimately what needs to be defined and navigated through is the difference between JSpOC and CSpOC working environments for improved SSA. This effort will confront multi-national issues for the JSpOC Mission System (JMS) before the system, and in particular the UDOP, become too big to incorporate changes.

PHASE I: Design a concept for a human-computer interface that supports multi-national space situational awareness with a focus on ISR. Other areas are also performed jointly – including Position, Navigation, and Timing (PNT), Satellite Communication, Missile Warning, and Environmental Monitoring – but these would be considered above and beyond the scope of this effort. The end product of this phase will include a technical report that outlines the approach for Phase II and the completed system. The concept description will need to address how the technology will integrate with or augment existing capabilities used in space operations centers.

PHASE II: Develop, demonstrate and validate the human-system interface software in a relevant environment that closely corresponds to an actual multi-national space operations center. By successfully demonstrating in a relevant environment, the software should obtain a Technology Readiness Level of 5.

PHASE III: With the expanding global satellite services industry, multi-national space operations are not unique to the military. This capability will also be valuable to the commercial space industries that need to coordinate operations across multi-national companies. The software will interface with many other space monitoring and

information tools, yet maintain a unified look and feel for the user. In addition to the software, the small business could be in a good position to act as a consultant for any enterprise interested in multi-national space operations.

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KEYWORDS: Space situational awareness, SSA, Joint Space Operations Center, JSpOC, multi-national, user defined operational picture, UDOP, cognitive support, work-centered support

SB122-010 TITLE: Space Signatures for Rapid Unambiguous Identification of Satellites

TECHNOLOGY AREAS: Sensors, Battlespace, 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Define and demonstrate approaches to establish and maintain rapid and reliable positive object identification of individual satellites in orbit through sparse but regular data collection.

DESCRIPTION: Current methodologies supporting the maintenance of the satellite catalog based upon information derived from the Space Surveillance Network are inadequate to enable a proactive approach to certain issues relevant to Space Situational Awareness (SSA). Among the challenges for SSA is the capability to maintain active custody of individual satellites. Some objects are frequently lost and sometimes serendipitously reacquired without recognition of its previous catalog existence unless manpower-intensive analysis intervenes to uncover the situation for some cases. Maintaining custody of a large number of satellites is a leap in capability requiring innovative solutions that are amenable to automation in order to be feasible for implementation.

The challenge of maintaining custody is magnified in certain crowded regions of space by the sheer number of objects present, the fact that most active satellites perform periodic but unannounced maneuvers for orbit and/or attitude corrections, dynamical models are approximate, and a certain number of faint objects are marginally detectable thus forming a sort of background clutter. Active custody encompasses the indication for when objects are missing, action to identify and search likely regions for reacquisition, and positive identification of a reacquired object as the previously missing object. Timeliness and accuracy in the identification of reacquired objects are key performance metrics.

Positive identification of satellites is linked to defining signatures that are predictable and uniquely indicating the presence of some feature(s) of an object, manifesting from its physical and/or operational attributes. For objects in

space, signatures may stem from any observable phenomenology that may be remotely sensed from ground-based or space-based instrumentation.

A collection of appropriately selected signatures may be sufficient to unambiguously identify individual satellites, even among those of common manufacturers and of similar bus types. Combining signature information with orbital dynamics modeling may increase confidence in the identification of reacquired objects.

PHASE I: Develop an initial concept design and model key elements for a feasible approach to establish and maintain positive identification of individual satellites, including active payloads and tumbling objects. Phase I deliverables will include a detailed report of the chosen approach.

PHASE II: Develop, demonstrate, and validate through high simulation and/or real data if suitable test cases are available the approach proposed in Phase I. Develop a detailed mathematical or parametric relationship between available observation data and the probability of maintaining custody. Initial target TRL at beginning of Phase II effort is 2, and target TRL at conclusion of Phase II is 5. Required Phase II deliverables will include documented algorithms, detailed reports of validation efforts and findings, and software implementations used to demonstrate and validate the approach.

PHASE III: Most likely path for transition of this effort is through the Joint Space Operations Center (JSpOC) Mission System (JMS) with the end user being the JSpOC. Additional efforts may be required to mature the technology to TRL 6. Potential commercial applications include establishing attribution for radio frequency interference or any other actions that may result in loss of service to the detriment of a payload operator.

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KEYWORDS: Satellite discrimination, object custody, maneuver detection, space signatures, satellite identification