DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)
12.3 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 12.3 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 12.3 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 $500,000.

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 12.3 Topic Index

SB123-001	Adhesive Bond Strength of Bonded Structures in Confined Locations
SB123-002	Indexing large scientific data
SB123-003	Rapid, Low-Cost, and High-Fidelity DNA Synthesis and Assembly Techniques
SB123-004	Realtime interlinked software for distributed Non-latent N-DOF operations

DARPA SBIR 12.3 Topic Descriptions

SB123-001 TITLE: Adhesive Bond Strength of Bonded Structures in Confined Locations

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an inspection system to measure the adhesive bond strength for bonded composite structures that are contained near edges or in confined spaces.

DESCRIPTION: Bonded composite materials offer considerable opportunity to reduce manufacturing cost, improve structural performance, and improve fuel efficiency of aircraft. However, bonded composite aircraft structures continue to be a challenge to manufacture due to the certification requirement to determine the strength of the bonds in the structures - before they are placed into service. Current testing techniques involve statically loading the bonded structure to some specified load level to place the bond line under load. If the bond does not fail, it is determined to be acceptable and the structure is placed into service. This test method is costly and time consuming to undertake.

There is a need to be able to "proof" test these bonds to quantify their strength with an efficient nondestructive method. A reliable and repeatable system for inspecting bonds would eliminate the need for full scale load testing resulting in a savings of $20 million in the aerospace industry alone. Recent developments with the use of well controlled stress waves have been demonstrated to be able to locally proof test the bond line. This bond inspection method has been matured for the inspection of non-confined structures. Non-confined bonded structures include wing skins bonded to the main spar or other internal structures.

Challenges to implementation of an inspection process include the identification of data and inspection criteria/requirements (to address confined bonded structures and to define the system requirements for the inspection of these confined structures). The laser bond inspection process may provide verification of a successful bond and obviate the need for expensive global proof load tests. Discussions with Original Equipment Manufacturer (OEM)/Tier 1 designers and nondestructive inspection (NDI) personnel have yielded insufficient definition of these inspection requirements, as the designers often make design choices based on available NDI capability. NDI personnel would like the design community to provide requirements on what NDI resolution is needed for the structure.

This leaves NDI equipment providers at a disadvantage and impedes further development of technology needed for the equipment/method to inspect primary bonded structures. The nondestructive inspection method shall be capable of proof testing the strength of confined adhesively-bonded composite structures. The identification of the confined structures with an OEM is to be used to determine the equipment requirements for the system to inspect confined structures. The research should identify approaches for measuring the strength and then demonstrating the ability to actually quantify the strength of a confined structure.

PHASE I: Define the requirements for inspection system hardware that can quantify the strength of adhesive bond joints in composite structures, such as Pi joints that are contained within confined spaces. Define the dimensions of confined space with a vehicle OEM and then identify and evaluate hardware concepts with the potential to inspect bonds located in realistic vehicle confined spaces.

PHASE II: Design the inspection hardware based upon one of the concepts defined in Phase I that addresses the inspection needs of bonded composite structures. Construct a functional breadboard inspection head and demonstrate its ability to conduct inspections within a confined space structure.

PHASE III DUAL USE APPLICATIONS: The compact inspection head would apply to inspection of commercial aircraft and automotive bondments, as well as high end recreational marine structures. DoD applications consist of bonded manned and unmanned vehicle systems to include air, ground, and sea platforms.

REFERENCES:

1) R. Bossi, K. Housen, and C. Walters, and D Sokol, “Laser Bond Testing” Materials Evaluation July 2009 pp 819-827.

2) Baker A.A., Jones R. Bonded Repair of Aircraft Structures, Martinus Nijhoff, 1988.

3) Tenney, Darrel R.; Davis, John G., Jr.; Pipes, R. Byron; Johnston, Norman, "NASA Composite Materials Development: Lessons Learned and Future Challenges," NATO RTO AVT-164 Workshop on Support of Composite Systems; 19-22 Oct. 2009; Bonn; Germany.

KEYWORDS: bonded; joints; adhesive; bondline, composite; laser, NDE, NDI

SB123-002 TITLE: Indexing large scientific data

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop new indexing schemes for large heterogeneous data that operate within a cloud-computing framework in order to enable rapid search and analytics.

DESCRIPTION: Data continue to be generated and digitally archived at increasing rates, resulting in large volumes available for search and analysis. Access to these volumes has generated new insights through data-driven methods in commerce, science, and computing sectors. Processing data at the requisite scale now requires specialized databases or clusters of computers, necessitating distributed computing paradigms for data ingestion, transformation, and loading for distributed computation. Therefore it is critical to develop fast, scalable, and efficient indexing schemes for data that not only support data ingestion and transformation but also enable fast search and analytics.

Bulk data processing models like MapReduce enable users to leverage the power of thousands of commodity machines with little programming effort within easy-to-use software stacks [1]. Its open source implementation Hadoop has been primarily used to index large collections of text documents for search by exact match string comparison [2-4].

However, little progress has been made in indexing heterogeneous scientific data: semi-structured documents with meta-data and free-text, schema-less structured files, spatial measurements from sensors, categorical data with possibly missing values, noisy measurements, video, speech, graphical/networked information, as well as other data types coming from scientific measurements by instruments.

In this solicitation, we seek new indexing schemes for large heterogeneous scientific data that operate within a cloud-computing framework. As most existing implementations of MapReduce do not provide underlying data indexing, new indexing schemes are sought to improve performance for jobs that join data across distinct inputs as well for jobs requiring more descriptive classes of search criteria. Schemes are also sought that support iterative algorithms and successive search refinement, which arise in applications such as mining, ranking, traversal, and parameter estimation.

A technical challenge to building indices is to address uncertainty in data that has the potential to bias resultant analysis and lead to erroneous conclusions. For example, it is infeasible for a sensor database to contain the exact value of each sensor at all points in time. This uncertainty is inherent from measurement and sampling errors as well as from resource limitations. In categorical data, a correct value of an attribute is often unknown but may be selected from a number of alternatives. Current research and technology does not incorporate a rigorous method for representing, propagating, or manipulating this type of uncertainty.

We seek index structures for efficiently searching uncertain categorical data as well as index structures that intentionally approximate values for speed and efficient implementation, along with corresponding performance guarantees from the probabilistic queries they enable.

Another challenge is indexing scientific data using both foreground and background information. The effectiveness of text indices for reliable web search can partly be attributed to the inverted index, where both term frequency and inverse document frequency contribute to the match between document and query. There are not well developed analogues to this combination for scientific data, and therefore we seek novel approaches for indexing scientific data that include similar foreground and background information toward a relevant match.

Finally, efficient indexing methods for streaming data are lacking. Existing cloud-computing methods primarily focus on storage and query techniques for sets of static data. We also seek indexing schemes designed to operate on data that appear as continuous and rapid streams.
The effort should also develop data annotations to provide an effective means to link data from diverse archives to a domain conceptualization, e.g., a formal vocabulary or grammar, which then provides users with an integrated view for querying the data.

PHASE I:
• Task 1: Develop an approach for scientific data with foreground and background information.
• Task 2: Develop an approach for indexing data with uncertainty.
• Task 3: Develop indexing methods for streaming data.
• Task 4: Extend methods to indexing heterogeneous data sets.
• Task 5: Implement a minimal proof-of-concept system with sample scientific datasets.

Phase I deliverables should include a Final Phase I report that includes: (1) a detailed description of the approach (or algorithms), and benefits of the selected approach over other alternatives; (2) an implementation architecture that integrates tasks 1-4; (3) a demonstration of the approach using the proof-of-concept system on a small cloud.

PHASE II: Develop a scalable implementation of the methods. Validate and demonstrate on a heterogeneous dataset in a significant cloud-computing environment. The required deliverable for Phase II will include: the full prototype system, demonstration and testing of the prototype system on users, quantification of performance metrics including number of simultaneous queries per server, number of records indexed, latency, etc., and a Final Report.

The Final Report will include (1) a detailed design of the system, documentation, and technical and user manuals, and (2) a plan for Phase III.

PHASE III DUAL USE APPLICATIONS: Being able to efficiently and effectively index large scientifically collected data would impact many DARPA efforts to build and deploy instruments such as sensors. Also, it would enable new classes of problem solving in the information processing domain relevant to several on-going efforts at DARPA. The Department of Defense has many applications where scientifically collected information is unable to be stored and used in later stages of information processing and decision making because of size and inherent format. Unlike text documents and reports, where indexing and processing have been standard, scientific data such as sensor measurements have not been effectively incorporated into the process.

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KEYWORDS: Big data, Heterogeneous scientific data, Indexing, Indices, Search, Uncertainty, Streaming data

SB123-003 TITLE: Rapid, Low-Cost, and High-Fidelity DNA Synthesis and Assembly Techniques

TECHNOLOGY AREAS: Materials/Processes, Biomedical

OBJECTIVE: Develop a platform based on novel DNA synthesis and assembly techniques that can produce sequence-verified, dsDNA constructs of at least 20,000 bp in length (including A/T- and G/C- rich sequences), at a cost of less than $0.05/bp, and with a turn time of less than one week.

DESCRIPTION: Current approaches to engineering biology rely on an ad hoc, laborious, trial-and-error process, wherein one successful project often does not translate to enabling subsequent new designs. As a result, the state of the art development cycle for engineering new biologically based products and capabilities often takes 7+ years and costs tens to hundreds of millions of dollars (e.g. microbial production of artemisinic acid for the treatment of malaria and the non-petroleum-based production 1,3-propanediol). The impact of current approaches is two-fold. First, the number of new entrants and innovators into both the commercial and research space is immediately limited – few have the expertise, capital and/or time necessary to develop and engineer a new product. Second, combined with the inherent complexity of biology, an ad hoc approach often results in one-off efforts that are limited to modifying only a small set of genes and constructing simple, isolated systems and devices. Consequently, while progress has been made, we are constrained to producing only a tiny fraction of the vast number of possible chemicals, materials, diagnostics, therapeutics, and fuels that would be enabled by the ability to truly engineer biology. A new approach is needed.

Engineering biology with useful complexity requires new approaches for synthesizing, assembling, and manipulating genetic designs rapidly, cheaply, and accurately. The goal is to shift the designers' mindset towards design and experimentation and to facilitate more complex, previously unattainable system designs and architectures. Unlike computer programming, where writing and producing variants of new code is essentially free, the synthesis and assembly of large DNA constructs (the writing of 'biological code') is expensive ($0.40 – $0.80 per bp), slow (2wks – 2mos turn time), error prone (~10-2 – 10-3), and limited in length and complexity (typically <5 kbp; A/T and G/C rich sequences are challenging or impossible to construct). These limitations restrict biological designers to constructing conservative, evolutionary designs, with little room for multiple design refinements, variants or new ideas. The ability to synthesize, modify and test many new designs (up to the genome scale) with little overhead will help to inform and create the biological design rules and tools that are necessary for the complex design and development of new biologically-based products and devices.

This solicitation is focused on development of a platform, based on novel DNA synthesis and assembly techniques, that can produce error-free, 20 kbp lengths of DNA at scale with a reduced cost per base pair (<$0.05/bp) and rapid turn time (<1wk) compared to the state of the art. A successful platform could be readily transitioned to academic, government, and commercial researchers, all of whom are dependent on DNA synthesis for the evaluation of new biological designs.

PHASE I: Determine the technical feasibility and projected cost at scale of the new approach for DNA construction. This includes determining the appropriate component processes for oligonucleotide synthesis, error correction, DNA assembly and verification methods, among others. Establish the performance goals of the new approach for cost per base pair, error rate, turn time, and maximum construct length. Perform appropriate analyses (e.g. modeling) to determine the limits to base pair length, error rate, cost, and turn time as well as limitations on A/T and G/C rich sequences for this approach. Develop an initial concept design and model key elements to transition this approach from benchtop to production at scale.

Phase I deliverables will include: a technical report of experiments supporting the feasibility of this approach; defined milestones and metrics for cost per base pair, error rate as a function of base pair length, maximum construct length, and turn time; and a detailed design of proposed manufacturing system with estimated production rate.

Also included with the Phase I deliverables is a Phase II proposal that outlines plans for the development, fabrication, and validation of a DNA synthesis and assembly platform. This proposal should include a detailed assessment of the potential path to commercialization, barriers to market entry, and collaborators or partners identified as early adopters for the new system.

PHASE II: Finalize the design from Phase I and initiate construction of and production from the new DNA synthesis and assembly platform. Establish performance parameters through experimentation to determine: sequence fidelity of oligonucleotides, assemblies and final constructs; cost per base pair of final assemblies; maximum feasible construct length; turn time and production rate of the DNA synthesis platform; and limitations on sequence complexity.

Develop, demonstrate, and validate a DNA synthesis and assembly platform that meets the key performance goals and metrics of sequence verified, dsDNA constructs of at least 20,000 bp in length (including A/T- and G/C- rich sequences), at a cost of less than $0.05/bp, and a turn time of less than one week. Deliverables include a prototype device and valid test data, appropriate for a commercial production path.

PHASE III DUAL USE APPLICATIONS: The industrial biotechnology and pharmaceutical sectors are deeply reliant on synthetic DNA constructs to produce novel and high value products. A successful DNA synthesis platform that achieves the key metrics stated for Phase II has significant potential to rapidly transition to commercial use, enabling the biologically-based production of new chemicals, enzymes, fuels, diagnostics, therapeutics, and industrial products.

A successful DNA synthesis platform will enable the rapid programming of biologically-based manufacturing platforms through synthesis and assembly of DNA 'code' for the production of previously unattainable technologies and products. Such technologies may support a number of current DoD challenges in the areas of novel materials production, diagnostics and vaccine development, as well as enabling new manufacturing capabilities and paradigms. For example, the capability to program systems to rapidly and dynamically prevent, seek out, identify, and repair corrosion/materials degradation in situ—a challenge which costs the DoD $23B/yr and has no near term solution in sight.

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KEYWORDS: Biomanufacturing, Bioengineering, Biology, Biotechnology, DNA Synthesis, DNA Assembly, Gene Synthesis, Genomics, Synthetic Biology, Oligonucleotides

SB123-004 TITLE: Realtime interlinked software for distributed Non-latent N-DOF operations

TECHNOLOGY AREAS: Information Systems, Space Platforms

OBJECTIVE: Create and link a nationally distributed network of very low cost space-simulated N-degree of freedom (DOF) test beds using a common open source set of real-time software.

DESCRIPTION: The US has more independent multi-DOF test beds that support various robotic or free-flying demonstration spaces for space systems than anywhere in the world. However, they are each independent and geographically disparate, and each location develops its own methodology to simulate the space environment based on the numbers of degree of freedom's the facility has at its disposal. The problem to solve is a common set of simulation software that is able to link each of these various N-DOF's together into a real-time 6-DOF simulation that could run concurrent test operations at a fraction of the cost of flying similar systems in space.

Goal is to develop a nationally linked test and operations methodology that can train, increase the Technology Readiness Level (TRL) and demonstrate low cost space technology using the high number of separated multi-DOF test beds around the nation. The objectives is to link in 3-D visualization technology with test beds for full scale DOF flight operations and methodologies, demonstrated using various N-DOF geographically distributed test beds that concentrate on robotic dynamics, orbital contact dynamics and 1-G contact dynamics.

Relevance to DoD/DARPA will include a never before demonstrated methodology to train multiple personnel (from students to professional engineers) on upcoming techniques for rendezvous proximity operations in space, and to develop a methodology to test both hardware and techniques in terrestrial test beds at a cost point that has here-to-fore never been achieved except by going into space. Terrestrial laboratories and hardware can be tested, modified, re-tested in the course of hours or days, whereas a space test, even on the International Space Station (ISS), takes years of planning and then has no capacity to be modified to re-test.

PHASE I: Investigate and develop the basic concept behind a common architecture set of simulation software that would interlink multiple DOF test beds. This would include identifying a basic set of inertial matrices that could be used no matter the DOF's available at each location; identify methodology for latency compensation due to internet communication breaks that would affect real-time operations; and identify appropriate and realistic DOF fusion that could occur to address various disparate test facility differences in X, Y and Z axes such that combinations of 2 or more could provide full real-time 6DOF simulations.

PHASE II: Deliver an open source based set of software standards and algorithms that can be used by various test facilities around the country that can integrated multiple DOF's. An actual demonstration of fusion into 6 DOF will be shown by selecting at least two facilities and implementing the software into the test facilities robotic platforms. The software deliverable at the end of Phase II should be fully realizable in an open source language, and have the ability to interconnect various simulation systems specific to DOF test facilities through internet accessible languages and protocols.

PHASE III DUAL USE APPLICATIONS: The vision for Phase III is a full complement of software and modules that can be used by the DoD laboratories associated with space applications, and civilian research and organizations worldwide that support space systems development through N-DOF tests. This would potentially apply to any and all spacecraft hardware that to-date has not been able to be tested in full 6-DOF capability without going to space, and expanded to new hardware and systems concepts for upcoming activities in spacecraft servicing and advanced rendezvous and proximity maneuvering operations for on-orbit assembly, salvage, repair and maintenance of satellite and space based platforms.

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KEYWORDS: N-degree of freedom, test facilities, space simulation, 6-DOF algorithms, open source software