

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)**  
**12.A Small Business Technology Transfer (STTR)**  
**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 Technology Transfer (STTR) 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](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.A STTR 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.A STTR 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**

A Phase I Cost Proposal must be submitted in detail online via the DoD SBIR/STTR submission system. Proposers that participate in this solicitation are REQUIRED to use the online cost proposal (available on the DoD SBIR/STTR submission site) for the Phase I cost, not to exceed the maximum dollar amount of \$100,000. 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 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.

A Phase II Cost Proposal must be submitted in detail online via the DoD SBIR/STTR submission system. Proposers that submit a Phase II proposal are REQUIRED to use the online cost proposal (available on the DoD SBIR/STTR submission site) for the Phase II costs, not to exceed the maximum dollar amount of \$750,000. 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 are subject to the availability of funds.

#### **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 STTR 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 STTR 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 STTR 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.

#### **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](http://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](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 \$375,000 each. The entire Phase II base effort should generally not exceed \$750,000.

### **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.pmdt.state.gov/regulations\\_laws/itar.html](http://www.pmdt.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](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](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](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](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](mailto: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 STTR 12.A Topic Index

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## DARPA STTR 12.A Topic Descriptions

SB12A-001

TITLE: Ultra-stable, Portable Fabry-Perot Cavities

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop ultra-stable, vibration-insensitive portable Fabry-Perot laser cavities that can operate in a wide range of environments such as high-g and fluctuating temperatures.

DESCRIPTION: Frequency and timing devices are essential components in modern military systems. The stability and accuracy of these devices impact the performance of communication, navigation, surveillance, and missile guidance systems. Atomic clocks are at the core of these systems, either directly or via time-transfer from a master clock. Currently, the most stable clocks rely on ultra-stable Fabry-Perot laser cavities for short-term clock stability. However, to achieve sub-hertz linewidths, these cavities require a vibration-isolated, temperature-controlled environment.

In order for optical clocks to operate in fieldable devices, the environmental sensitivity of the laser oscillators must be mitigated and the cavity size reduced. If such isolation and miniaturization is achieved, optical clocks may enable secure data routing, communication systems that are insensitive to jamming, higher-resolution coherent radar, and more reliable and robust global positioning. Furthermore, reduced environmental sensitivity may lead to commercialization of frequency-stable laser technology.

State-of-the-art frequency-stable laser cavities rely on the length-stability of a mechanical structure built from low expansion glass. Thermo-mechanical noise in the optical mirror coatings has been identified as the fundamental effect that limits the length, and hence, frequency stability of these cavities. Furthermore, laser cavities must operate inside a low-noise laboratory due to vibration and orientation sensitivity. This research will help develop fieldable versions of the world's narrowest linewidth lasers and, thus, lead to improvements in secure data routing, communication systems that are insensitive to jamming, higher resolution coherent radar, and more reliable and robust global positioning and precision time keeping. In addition, this research intends to stimulate hitherto unknown processes that will lead to significant improvements in performance, portability and ruggedness.

PHASE I: Design a Fabry-Perot laser cavity and identify its advantages over current state-of-the-art devices. Advantages may include vibration isolation, temperature sensitivity, long term stability and/or miniaturization. Ideally, the chosen cavity design should be sufficiently isolated from the environment to achieve frequency stability better than  $10^{-15}$  in 1 second and acceleration sensitivity better than  $10^{-11}/g$ .

Approaches for a monolithic, high-quality optical whispering gallery mode resonator would be of interest. Such resonators should be highly portable with sizes on the millimeter scale, and would not suffer from thermal noise due to optical coatings. Approaches for miniature, portable and environmentally insensitive Fabry-Perot resonators made from low expansion glass or atomic standards based on spectral hole burning in doped crystals are also of interest.

Exhibit the feasibility of the approach through a laboratory demonstration. Phase I deliverables will include a design review including expected device performance, laboratory test data, and a report presenting the plans for Phase II.

Phase II: Fabricate the device and perform laboratory experiments to quantify the device performance in the presence of real-world relevant temperature and vibrational perturbations. Phase II deliverables will include a report detailing the fabrication procedure and laboratory test results.

PHASE III: Vibration-insensitive portable Fabry-Perot cavities may enable improvements in secure data routing, communication systems that are insensitive to jamming, higher resolution coherent radar, and more reliable and robust global positioning. Insensitivity to environmental perturbations may lead to the commercialization of frequency stable laser technology. Innovations in Phases I and II will enable such devices to transition out of the laboratory and into fieldable devices. Potential government end users include all branches of the military and other domestic agencies. Potential commercial end users include the telecommunications, electronics, and timekeeping industries.

#### REFERENCES:

1. Diddams, S.A., Bergquist, J.C., Jefferts, S.R. & Oates, C.W. Standards of Time and Frequency at the Outset of the 21st Century. *Science* 306, 1318 -1324 (2004).
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3. Young, B.C., Cruz, F.C., Itano, W.M. & Bergquist, J.C. Visible Lasers with Subhertz Linewidths. *Phys. Rev. Lett.* 82, 3799 (1999).
4. Numata, K., Kemery, A. & Camp, J. Thermal-Noise Limit in the Frequency Stabilization of Lasers with Rigid Cavities. *Phys. Rev. Lett.* 93, 250602 (2004).
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KEYWORDS: Fabry-Perot resonator, frequency stability, optical clock, laser linewidth

SB12A-002

TITLE: Design of Robot Control Interfaces

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a design science for robot operator interface and demonstrate its application through design tools or prototype systems that significantly reduce operator training time and maximize the ability of an operator - robot team to maintain synchronization with the normal operational tempo of military operations.

DESCRIPTION: Significant training time is presently required for operators of existing robotic systems, particularly unmanned ground systems (UGV's). Even with such training, maintaining an acceptable operation tempo is difficult.

Recent improvements in small and efficient terrain surveillance sensors can provide a basis for improved low-level autonomy that could reduce operator loading. At present, interface design is more of an art than a science and interface designers frequently depend excessively on the adaptability users. It is believed that improvement in the operator interface will provide significant payoff by reducing training costs and improving military effectiveness of current robot platforms enhanced with improved sensor systems.

PHASE I: Develop the principles of an operator interface design science, including:

- Metrics that will support effective assessment of operator interface design performance in operational conditions including cognitive load, ease of use, error rate, operator training time, as well as comfort and fatigue.
- Techniques that could enhance operator interaction with interface modalities such as gesture, eye tracking, speech, function selection, body position and haptic feedback.
- Managed autonomy level depending on the nature of the function to be controlled and the operational conditions.
- At least the outline of a robot--centered control ontology that reflects the effective capability limitations of a robot rather than the current ontology that includes the rich contextual understanding based on human experience. Terms like “door” or “dog” imply a context knowledge that is not currently available to a robot situation understanding capability.
- Action scenarios and terrain types that reflect the range of operational conditions that a robot might encounter.

- Displays that promote joint situation understanding by both the operator and the robot.

Phase I deliverables should include a document summarizing the conclusions reached in this Phase and a final Phase I report that will include:

- 1) A high level compilation of existing research and the approaches suggested in this phase and
- 2) A Phase II plan.

PHASE II: Applying the principles of the design science developed in Phase I, develop components, design processes, or prototype systems to a point where effective interface design concepts can be evaluated. These include:

- A substantive body of performance metrics for the overall system design and the components of an operator interface whose effectiveness has been demonstrated and evaluated.
- Evaluation of the effectiveness of candidate operator interface modalities with specific reference to their performance relative to sub-components of a suite of action scenarios and an overall operator interface design.
- Testing and demonstration of a conceptual system that will adjust, either automatically, or by operator interaction, the level of the interface between the operator and supervised autonomy functions.
- Structuring a robot--centered control ontology that supports operator understanding of the current effective state of the robot. If possible, the development of this ontology should be directed towards its becoming an open and public standard.
- A catalog of action scenarios and sub- states of these scenarios, including terrain conditions that will encompass the range of situations that might be encountered in operational conditions.
- A catalog of display techniques for enhancing situation understanding and supporting effective operator--robot control interaction.

Required Phase II deliverables will include:

- 1) A Final Report
- 2) A Phase III plan.
- 3) Publication of the results of the program including a discussion of the capability level reached and demonstrated for each of the areas listed above.

PHASE III: Transition the work of phase II to a fielded DoD and potentially commercial robotic system. Robotic systems are already in use in surgery, patient care, and medical logistics, as well as EOD and ISR missions. Improved operator interface design should reduce training time and increase ease of use. Robots are also in limited use in manufacturing fabrication and logistics. One problem area is reprogramming such systems for changes in production schedule or component design. Better operator interface designs should reduce the skill levels required. Thus, wider use of robotic systems from existing manufacturers and newly formed firms is probable.

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KEYWORDS: Robotics, operator interface design, operator interface modalities, managed autonomy, adaptive control, design requirements, process improvement

SB12A-003

TITLE: Applications and Methods for Continuous Monitoring of Physiological Chemistry

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop advanced reagents and technologies for continuous monitoring sensors used for clinically valid, health diagnostic applications. Developments are sought that will improve the performance and applicability of sensors capable of continuously monitoring an individual's chemistry as a measurement of physiological status. Topics of specific interest include development of materials and devices for improved performance as well as reagents, such as synthetic enzymes, optimized for use in an implanted biosensor. Anticipated outcomes are new commercial products that address the need for continuous monitoring of DoD-relevant biomarkers (e.g. peptidic hormones, histamine, cortisol) for clinical guidance or performance assessments, via developments in two key areas: new reagents and new continuous monitoring devices.

DESCRIPTION: The measurement of biomarkers from a collected biospecimen (eg. urine, saliva, phlebotomized blood) is regularly used in the clinic to inform the decisions of a medical care provider. The majority of these measurements suffer from poor reliability and utility because of biospecimen-related issues such as: delay in information caused by overnight shipping to a centralized laboratory; pre-analytical variability associated with collection, processing and handling; and the inability to account for intra-patient variability (such as diet, diurnal variations, exercise, etc.).

There is a need to develop health diagnostic tools that are not dependent on the collection of a biospecimen and have the ability to continuously measure biomarkers directly and in real-time. Continuous monitoring of transient biomarkers using implantable sensors is extremely challenging. Current sensor technologies are limited by factors such as device size, biofouling, clinical accuracy, limited multiplex capability, and lack of quality receptors for clinical analytes.

Advances are needed to address materials issues related to biocompatibility and sensor design issues related to analytical performance. In addition, robust receptors and affinity reagents are needed to allow measurement of a diversity of analyte classes and types. For example, glucose oxidase is widely used for glucose detection but expansion of this technical approach to exploit other optimized enzymatic reactions for the diagnosis or monitoring of other disease conditions is limited to the availability of enzymes or receptors that are fit for in-vivo use.

Proposals are sought for technology solutions capable of continuous or near-continuous measurements of biomarkers without the need to extract and transport a biospecimen. Proposers are encouraged to: consider platform approaches that can be used to develop reagents that expand continuous monitoring capabilities to other analytes beyond glucose, consider targets that meet current needs in US healthcare, to develop technologies that could also be applied toward the measurements of non- metabolite biomarker classes (such as proteins and nucleic acids), and develop a plan that if technically feasible would address a pathway toward appropriate regulatory clearance.

PHASE I: Demonstrate in vitro feasibility of reagents/receptors/devices to continuously and reliably measure clinically relevant biomarkers over a duration of time using a wide, physiologically-relevant concentration range in buffered media. Proposers should select biomarkers for which continuous monitoring can be correlated to a clinical or performance outcome (such cortisol or histamine). Preferred are platform methodologies that can be applied for

the detection of a variety of biomarkers. Proposals addressing only receptor or enzyme development should demonstrate preliminary results appropriate for the maturity of the method, and address how their approach can be applied to a variety of detection technologies. Proposals focusing on device development should justify how the chosen conditions mimic the targeted sampling site in-vivo. For example, biofouling issues differ for devices implanted within interstitial and capillary sites, and proposals should address plans for overcoming such challenges. Device designs should describe how other effects common to foreign body implantation and residence - such as localized inflammation, device encapsulation, and toxicity/degradation - are addressed. Approaches should also address anticipated lifetime of the device (with a goal of minimizing surgical implant/removal procedures), calibration methodology, and data retrieval. Methods that are in accordance or exceed those outlined in U.S. Food and Drug Administration (FDA) recommendations are encouraged.

PHASE II: Proposals developing new receptors or synthetic enzyme production methods should demonstrate and quantitate the production (e.g. yield) and the performance of the receptor. Deliverables of reagent(s) and supporting validation data, appropriate for a commercial production path, are expected. Such approaches should aim to be agnostic to the detection technology.

For device development, develop and optimize an integrated prototype device capable of achieving the objective goals as described above. Deliverables of a prototype device and valid test data, appropriate for a commercial production path, are expected. In vitro experiments should be conducted using biospecimens and/or animal models appropriate for the biomarker target and sampling site. Experiments should use metrics that demonstrate minimal biofouling effects, optimized specificity and sensitivity, maintained calibration over a time period that reflects the residence time of the device within the user, and methods for data output. Efforts should demonstrate technologies using clinically relevant sample concentrations. Device potential for FDA clearance as a continuously monitored and implanted device should be described.

PHASE III: The technology to be developed is applicable to continuously monitor physiological chemistry for diagnosis or performance measurements. There is a significant commercial market for medical diagnostics, particularly those currently involved in the development of technologies capable of the continuous monitoring of glucose and other metabolites. The developed technology would allow improvement of existing tests for diabetes and expansion of tests for monitoring of additional health conditions.

The technology to be developed is applicable to continuous monitoring diagnostics. Transition customers include Military Health System - Defense Medical Research and Development Program (MHS DMRDP), Military Infectious Diseases Research Program (MIDRP), and Defense Threat Reduction Agency (DTRA).

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KEYWORDS: Enzyme, molecular recognition, receptor, in-vivo, sensor, implantable, diagnostic.

SB12A-004

TITLE: Visualization, Human Systems, Information Systems

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop methods and tools for the automatic generation of visualizations and user interactions to dynamically generate visualizations of social networks and associated data in order to aid analysts in the discovery

and understanding of social networks, memes, and associated trends. Methods and tools will be based on extensive existing research and established principles from cognitive science and cognitive neuroscience [see References].

**DESCRIPTION:** In recent years, work in the characterization and discovery of social networks has dramatically increased. Massive amounts of social network data are collected for military, government and commercial purposes. Social network analytics are used to both discover social networks within larger populations and to gain an understanding of these networks. This includes understanding the various network topologies, interactions within and between social networks, mapping information flows as well as the flows of more abstract concepts such as memes, power/influence, and control.

In effective analysis systems, visualizations are tuned to a problem space (i.e. analytic), a data set, and a user community. This leads to a time-consuming process of knowledge engineering, design and software engineering. At the same time, the problem space is constantly and rapidly changing. That is, the characteristics of networks we need to identify and understand are changing at a pace well inside the design & engineering times of the tools being built to provide analytical capabilities. This is due to changes in operational problems and behaviors of social networks as well as advances in collection that make new analyses possible.

Current visualizations of social network data are primarily limited to link-node diagrams which have been shown to be only minimally effective in providing a deep understanding of a number of critical aspects of social networks. Therefore, a new approach is required - the dynamic generation of visualizations (and interactions). There has been a good amount of work in this area with some limited successes. However, in recent years, research in the human visual system has made great strides and can provide a rich source of information for the effective and efficient presentation of information to users. Of particular interest are applications that follow from cognitive science and cognitive neuroscience, particularly in the domains of perception and memory. Examples are principles, based on empirical findings, for presenting information effectively in graphs [10, 11]. In these examples, use is made of information about the number of elements that can be held in mind at once, the size labels must be in order to be read easily, and so forth, but also exploit implications of some relatively subtle effects arising from the range of spatial frequency channels in vision, the separation of the "what" and "where" visual pathways, and the like.

DARPA is interested in the application of established cognitive and design 'first principles' and the demonstration and development of a system that can dynamically generate visualizations and interactions from these first principles based on interactions with users. An algorithmic approach to application and combination of these principles combined with goal definition and prioritization from the user will need to be developed. As user goals, prioritization, and data change, the system will dynamically create visualizations that are optimally tuned to the problem and user.

#### PHASE I:

- Task 1: Develop an approach for capturing and encoding design rules and cognitive principles. The rules should be as close to 'first principles' as possible and handle meta-rules as well (valid combination of 'first principles').
- Task 2: Develop an approach for the application and combination of the cognitive principles (from task 1).
- Task 3: Develop an architecture and conceptual design for the implementation of a dynamic system based on the principles developed in task 2.
- Task 4: Implement a minimal proof-of-concept system that can take some set of principles and generate visualizations based on user inputs for goals, data, and prioritization of output.

Phase I deliverables should include a Final Phase I report that includes: (1) a detailed description of the approach (or algorithm) for applying established cognitive principles to a specific data set and user-defined goal; (2) a detailed system architecture and design; (3) a demonstration of the approach using the proof-of-concept system.

**PHASE II:** Develop, demonstrate, and validate a proof of concept design of the dynamic visualization generation tool. The required deliverable for Phase II will include: the full prototype system, demonstration and testing of the prototype system on users, and a Final Report.

The Final Report will include (1) a detailed design of the prototype tool, (2) the experimental results from the tool, and (3) a plan for Phase III.

PHASE III: Phase III will consist of the delivery of systems to social network analysts in DoD and/or commercial operational settings.

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KEYWORDS: Social Media, Dynamic Visualization, Social Networks, Discovery, Meme

SB12A-005

TITLE: Closed Loop Frequency Control for Tunable High Quality Factor Filters

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Develop and demonstrate innovative closed-loop control mechanisms for high quality factor Radio Frequency filters or banks of filters for use in frequency-agile radio front-ends. Proposed concepts should focus on long term center frequency and bandwidth stability in addition to closed-loop control for microsecond-range frequency and bandwidth tuning over a wide spectral field of regard.

DESCRIPTION: Frequency-agile, waveform-agnostic cognitive and software-defined radios have been proposed as solutions to the growing problems of co-site interference and adversarial jamming encountered by modern military communication systems. Furthermore, the military and commercial industry have significant interest in developing widely deployed handheld radios with cognitive behavior; therefore, systems with low size, weight, power and cost

are of primary importance. An essential and enabling component for such platforms are pre-select banks of low-loss filters capable of center-frequency, bandwidth and shape-factor tuning and adaptable intermediate frequency (IF) filters.

Currently available static filters offer low loss and small form-factor but are not compatible with widely-tunable front-ends needed for true cognitive radio functionality. Consequently, significant research has been invested in developing MEMS, lumped-element, and cavity filters exhibiting adaptable bandwidth and wide (octave or greater) center-frequency tuning ranges. A significant remaining challenge, however, is tuning a given filter to a specific desired center frequency and bandwidth quickly and with commensurately short settlement times, particularly if the filter exhibits a high quality factor. Furthermore, any frequency-tunable element is susceptible to gradual drift with temperature or other factors that mandate continual stabilization through the use of a closed-loop control mechanism.

The goal of this STTR topic is to conceptualize and successfully demonstrate innovative closed-loop control mechanisms for the purposes of long-term frequency stability and microsecond-range tuning authority for RF or IF filter banks with low volume and power consumption while retaining high quality factor over a wide spectral field of regard (20 MHz – 30 GHz). This tuning mechanism should be intimately integrated with the tunable filter, either through monolithic single chip fabrication or through advanced heterogeneous integration capabilities. Complementary Metal Oxide Semiconductor (CMOS) compatibility is not explicitly required, but the advantages of co-integration with CMOS are highly valued in both commercial and military applications. The quality factor and tuning characteristics of the filter should be maintained with the introduction of closed loop control.

**PHASE I:** Conceptualize and design a closed-loop tuning mechanism for a bank of multiple tunable filters for RF pre-selection over the range of 20 MHz – 30 GHz or a bank of multiple tunable IF filters. Of specific interest is long-term frequency and bandwidth stability with respect to changing environmental conditions and micro-second range tuning speed. Tuning speed should account for ringing effects. Phase I deliverables will include simulation results of the proposed control concept and the path forward for fabrication in a well-established process.

**PHASE II:** Proposers will integrate the control mechanism with a tunable filter bank in a well established process and validate the Phase I simulation results. Demonstrate tuning control of center frequency and bandwidth and measure tuning speed and repeatability of tuning. Phase II deliverables will include prototype hardware developed under the effort and measurement results. Phase II efforts will fabricate simulated designs and demonstrate closed-loop tuning capabilities. Tests may be facilitated or assisted by a Government lab such as the Naval Research Lab (NRL) or Air Force Research Lab (AFRL).

**PHASE III:** Potential commercial applications include next generation cellular telephones, GPS receivers, tablet computers and other wireless devices where size and power are significant system constraints. New waveform and standards capabilities are enabled by the tuning control offered by this technology.

DoD/Military applications include military transceivers for communications, electronic warfare and signal intelligence platforms, especially systems for which size and power are significant system constraints. New waveform and standards capabilities are enabled by the tuning control offered by this technology.

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**KEYWORDS:** adaptive radio frequency technology; bandwidth; center frequency; closed-loop control; communications; complementary metal oxide semiconductor (CMOS)- compatible fabrication process; electronic warfare; front-end; handheld form-factor

SB12A-006

**TITLE:** Tunable High Quality Factor Radio Frequency Filters

**TECHNOLOGY AREAS:** Materials/Processes, Sensors, Electronics

**OBJECTIVE:** Develop and demonstrate innovative tunable Radio Frequency and/or Intermediate Frequency filters for use in frequency-agile front-ends for communications, electronic warfare and signal intelligence platforms. Proposed concepts should focus on center frequency and bandwidth tuning over a wide spectral field of regard and should clearly identify benefits over the current state-of-practice.

**DESCRIPTION:** Modern military and commercial communications systems often employ several dedicated front-end chains to provide coverage for a variety of wireless standards or waveforms. For instance, it is not uncommon for 4th generation cellular telephones to comprise dedicated receive chains for 802.11 WiFi, GPS, Bluetooth and one or more cellular standards. Typically preceding each receive chain is a dedicated static filter designed to reject out-of-band signals that could potentially saturate the low-noise amplifier or create undesirable mixing products. Since these filters are static in frequency and bandwidth, the functionality of such radios is essentially set at design time. Consequently, they are incapable of dynamically reacting to changing operating conditions that might render a certain channel undesirable.

The military is extremely interested in enabling this type of capability in its handheld and vehicle-mounted communications systems due to the growing threat of intentional adversarial jamming and increasing spectrum crowding from co-site transmitters. An emerging solution to the interference issue is the development of cognitive radio platforms that can tune on-the-fly to operate in under-utilized spectrum. A key enabling technology is a bank of front-end filters that can respond to changing conditions by tuning center frequency, bandwidth and/or shape factor.

Current state-of-the-art RF filters such as surface acoustic wave (SAW) or bulk acoustic wave (BAW) offer high quality factor, low volume and low power consumption; however, their tunability is severely limited or non-existent. The DARPA/MTO Adaptive RF Technology program has invested in tunable banks of RF-preselect filters; however, these filters are relatively wide in bandwidth and are large compared to state-of-the-art SAW and BAW filter implementations.

The goal of this STTR topic is to conceptualize and successfully demonstrate innovative tunable RF for IF filter banks with low volume and power consumption while retaining high quality factor over a wide, military-relevant spectral field of regard (20 MHz – 30 GHz). Ideally, the fabrication process for these filters would be fully CMOS-compatible. Alternatively, proposers could demonstrate the feasibility of a seamless heterogeneous post-CMOS integration process. Bandwidth, quality factor and filter shape should be specific to waveforms of interest that are clearly defined in the proposals. Likewise, input and output impedances are not limited to 50 Ohms; however, the choice of such impedances should be clearly justified as being compatible with a typical front-end system including assumptions for antenna and LNA impedances.

PHASE I: Conceptualize and design a bank of multiple tunable filters for RF pre-selection over the range of 20 MHz – 30 GHz or a bank of multiple tunable IF filters. Material choices should be well justified with reports of expected material properties, and the actuation mechanism and filter geometry should be established. Perform finite-element and/or abstracted model simulations to show tunable performance and applicability for a wide range of military and/or commercial waveforms specified by the proposer. Of specific interest is the tunability of center frequency, bandwidth and shape factor. Phase I deliverables will include simulation results of the proposed filter concept and the path forward for fabrication in a well-established process.

PHASE II: Proposers will fabricate the filter bank in a well established process and validate the Phase I simulation results. Demonstrate tuning of center frequency, bandwidth and shape factor to meet the requirements of the waveforms identified in Phase I. Measure tuning speed and repeatability of tuning. Demonstration of closed-loop control of the filter bank is not explicitly required, but a process through which control can be achieved must be proposed. Phase II deliverables will include prototype hardware developed under the effort and measurement results. Tests may be facilitated or assisted by a Government lab such as NRL or AFRL. A demonstration of CMOS integration is not explicitly required in Phase II; however, a path to eventual integration must be clearly delineated.

PHASE III: Potential commercial applications include next generation cellular telephones, GPS receivers, tablet computers and other wireless devices where size and power are significant system constraints. New waveform and standards capabilities are enabled by the tunability of the developed filter banks.

DoD/Military applications include military transceivers for communications, electronic warfare and signal intelligence platforms, especially systems for which size and power are significant system constraints. New waveform and standards capabilities are enabled by the tunability of the developed filter banks.

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**KEYWORDS:** adaptive radio frequency technology; bandwidth; center frequency; communications; complementary metal oxide semiconductor (CMOS)- compatible fabrication process; electronic warfare; front-end; handheld form-factor; intermediate frequency