INTRODUCTION

The U.S. Army Combat Capabilities Development Command (CCDC) is responsible for execution of the Army SBIR Program. Information on the Army SBIR Program can be found at the following Website: https://www.armysbir.army.mil/.

Broad Agency Announcement (BAA), topic, and general questions regarding the SBIR Program should be addressed according to the DOD Program BAA. For technical questions about the topic during the pre-release period, contact the Topic Authors listed for each topic in the BAA. To obtain answers to technical questions during the formal BAA period, visit https://www.dodsbirsttr.mil/submissions/.

Specific questions pertaining to the Army SBIR Program should be submitted to:

Monroe Harden
Acting Program Manager, Army SBIR
usarmy.apg.ccdc.mbx.sbir-program-managers-helpdesk@mail.mil
U.S. Army Combat Capabilities Development Command
6662 Gunner Circle
Aberdeen Proving Ground, MD 21005-1322
TEL: 866-570-7247

The Army participates in three DOD SBIR BAAs each year. Proposals not conforming to the terms of this BAA will not be considered. Only Government personnel will evaluate proposals with the exception of technical personnel from Irving Burton Associates and ICON who will provide Advisory and Assistance Services to the Army and technical analysis in the evaluation of proposals submitted against Army topic numbers:

- A20-136 “Automated Encounter Documentation and Data Driven Decision Support Systems” (Irving Burton Associates)
- A20-137 “To Develop and Demonstrate an Advanced Combat Wound Care Technology that Prevents Sepsis from Infected Traumatized Tissue” (ICON)

The individuals from Irving Burton Associates and ICON will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. These institutions are expressly prohibited from competing for SBIR awards and from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the selection processes, the aforementioned institutions may require access to proprietary information contained in the offerors’ proposals. Therefore, pursuant to FAR 9.505-4, the institutions must execute an agreement that states that they will (1) protect the offerors’ information from unauthorized use or disclosure for as long as it remains propriety and (2) refrain from using the information for any purpose other than that for which it was furnished. These agreements will remain on file with the Army SBIR program management office at the address above.
PHASE I PROPOSAL SUBMISSION

SBIR Phase I proposals have three Volumes: Proposal Cover Sheet, Technical Volume, and Cost Volume. Please note that the Army will not be accepting a Volume Five (Supporting Documents), nor a Volume Six (Fraud, Waste and Abuse) as noted at the DOD SBIR website. The Technical Volume .pdf document has a 20-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any other attachments. Small businesses submitting a Phase I Proposal must use the DOD SBIR electronic proposal submission system (https://www.dodsbirsttr.mil/submissions/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheet, Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DOD SBIR Help Desk at 703-214-1333.

The small business will also need to register at the Army SBIR Small Business website: https://sbir.army.mil/SmallBusiness/ in order to receive information regarding proposal status/debriefings, summary reports, impact/transition stories, and Phase III plans. PLEASE NOTE: If this is your first time submitting an Army SBIR proposal, you will not be able to register your firm at the Army SBIR Small Business website until after all of the proposals have been downloaded and we have transferred your company information to the Army Small Business website. This can take up to one week after the end of the proposal submission period.

Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume such as descriptions of capability or intent in other sections of the proposal as these will count toward the 20-page limit.

Only the electronically generated Cover Sheets and Cost Volume are excluded from the 20-page limit. Army Phase I proposals submitted containing a Technical Volume .pdf document containing over 20 pages will be deemed NON-COMPLIANT and will not be evaluated. It is the responsibility of the Small Business to ensure that once the proposal is submitted and uploaded into the system that the technical volume .pdf document complies with the 20 page limit.

Phase I proposals must describe the "vision" or "end-state" of the research and the most likely strategy or path for transition of the SBIR project from research to an operational capability that satisfies one or more Army operational or technical requirements in a new or existing system, larger research program, or as a stand-alone product or service.

Phase I proposals will be reviewed for overall merit based upon the criteria in Section 6.0 of the DOD Program BAA.

<table>
<thead>
<tr>
<th>20.2 Phase I Key Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAA closes, proposals due</td>
</tr>
<tr>
<td>Phase I Evaluations</td>
</tr>
<tr>
<td>Phase I Selections Announced</td>
</tr>
<tr>
<td>Phase I Award Goal</td>
</tr>
</tbody>
</table>

*Subject to the Congressional Budget process
PHASE I OPTION MUST BE INCLUDED AS PART OF PHASE I PROPOSAL

The Army implements 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 efforts selected for Phase II awards through the Army’s competitive process will be eligible to have the Phase I Option exercised. The Phase I Option, which must be included as part of the Phase I proposal, should cover activities over a period of up to four months and describe appropriate initial Phase II activities that may lead to the successful demonstration of a product or technology. The Phase I Option must be included within the 20-page limit for the Phase I proposal. Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume such as descriptions of capability or intent, in other sections of the proposal as these will count toward the 20 page limit.

PHASE I COST VOLUME

A firm fixed price or cost plus fixed fee Phase I Cost Volume with maximum dollar amount of $167,500 must be submitted in detail online. Proposers that participate in this BAA must complete a Phase I Cost Volume not to exceed a maximum dollar amount of $111,500 for the six months base period and a Phase I Option Cost Volume not to exceed a maximum dollar amount of $56,000 for the four months option period. The Phase I and Phase I Option costs must be shown separately but may be presented side-by-side in a single Cost Volume. The Cost Volume DOES NOT count toward the 20-page Phase I proposal limitation when submitted via the submission site’s on-line form. When submitting the Cost Volume, complete the Cost Volume form on the DOD Submission site, versus submitting it within the body of the uploaded proposal.

PHASE II PROPOSAL SUBMISSION

Only Small Businesses that have been awarded a Phase I contract for a specific topic can submit a Phase II proposal for that topic. Small businesses submitting a Phase II Proposal must use the DOD SBIR electronic proposal submission system (https://www.dodsbirsttr.mil/submissions/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheet, the Cost Volume, and how to upload the Technical Volume, and the Company Commercialization Report. For general inquiries or problems with proposal electronic submission, contact the DOD Help Desk at 703-214-1333.

Army SBIR has four cycles in each FY for Phase II submission. A single Phase II proposal can be submitted by a Phase I awardee within one, and only one, of four submission cycles and must be submitted between 4 to 17 months from the Phase I contract award date. Any proposals that are not submitted within these four submission cycles and before 4 months or after 17 months from the contract award date will not be evaluated. The submission window opens at 0001hrs (12:01 AM) eastern time on the first day and closes at 2359 hrs (11:59 PM) eastern time on the last day. Any subsequent Phase II proposal (i.e., a second Phase II subsequent to the initial Phase II effort) shall be initiated by the Government Technical Point of Contact for the initial Phase II effort and must be approved by Army SBIR PM in advance.

The next available four Phase II submission cycles following the announcement of selections for the 20.1 BAA are:

2021(b) 1 Mar – 30 Mar 2021
2021(c) 15 Jun - 14 Jul 2021
2021(d) 2 Aug – 31 Aug 2021
2022(a) 15 Oct – 14 Nov 2021
PLEASE NOTE: Do not start entering your Phase II Proposal to the DOD Submission Website before the start date as any proposals started before the published start date and not submitted by the published end date will not be evaluated.

For other submission cycles see the schedule below, and always check with the Army SBIR Program Managers Office helpdesk for the exact dates.

<table>
<thead>
<tr>
<th>SUBMISSION CYCLES</th>
<th>TIMEFRAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle One</td>
<td>30 calendar days starting on or about 15 October*</td>
</tr>
<tr>
<td>Cycle Two</td>
<td>30 calendar days starting on or about 1 March*</td>
</tr>
<tr>
<td>Cycle Three</td>
<td>30 calendar days starting on or about 15 June*</td>
</tr>
<tr>
<td>Cycle Four</td>
<td>30 calendar days starting on or about 1 August*</td>
</tr>
</tbody>
</table>

*Submission cycles will open on the date listed unless it falls on a weekend or a Federal Holiday. In those cases, it will open on the next available business day.

Army SBIR Phase II Proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and the Company Commercialization Report. The Technical Volume .pdf document has a 38-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes), data assertions and any attachments. Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 38 page limit. As with the Phase I proposals, it is the proposing firm’s responsibility to verify that the Technical Volume .pdf document does not exceed the page limit after upload to the DOD SBIR/STTR Submission site.

Only the electronically generated Cover Sheet, Cost Volume and Company Commercialization Report are excluded from the 38-page Technical Volume.

Army Phase II Proposals submitted containing a Technical Volume .pdf document over 38 pages will be deemed NON-COMPLIANT and will not be evaluated.

Army Phase II Cost Volumes must contain a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of $1,100,000. During contract negotiation, the contracting officer may require a Cost Volume for year one and year two. The proposal cost volumes must be submitted using the Cost Volume format (accessible electronically on the DOD submission site), and may be presented side-by-side on a single Cost Volume Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. Phase II projects will be evaluated after the first year prior to extending funding for the second year.

Small businesses submitting a proposal are required to develop and submit a technology transition and commercialization plan describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal.

DOD is not obligated to make any awards under Phase I, II, or III. For specifics regarding the evaluation and award of Phase I or II contracts, please read the DOD Program BAA very carefully. Phase II proposals will be reviewed for overall merit based upon the criteria in Section 8.0 of the BAA.
BIO HAZARD MATERIAL AND RESEARCH INVOLVING ANIMAL OR HUMAN SUBJECTS

Any proposal involving the use of Bio Hazard Materials must identify in the Technical Volume whether the contractor has been certified by the Government to perform Bio Level - I, II or III work.

Companies should plan carefully for research involving animal or human subjects, or requiring access to government resources of any kind. Animal or human research must be based on formal protocols that are reviewed and approved both locally and through the Army's committee process. Resources such as equipment, reagents, samples, data, facilities, troops or recruits, and so forth, must all be arranged carefully. The few months available for a Phase I effort may preclude plans including these elements, unless coordinated before a contract is awarded.

FOREIGN NATIONALS

If the offeror proposes to use a foreign national(s) [any person who is NOT a citizen or national of the United States, a lawful permanent resident, or a protected individual as defined by 8 U.S.C. 1324b (a) (3) – refer to Section 3.5 of this BAA for definitions of “lawful permanent resident” and “protected individual”] as key personnel, they must be clearly identified. For foreign nationals, you must provide country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. Please ensure no Privacy Act information is included in this submittal.

OZONE CHEMICALS

Class I Ozone Depleting Chemicals/Ozone Depleting Substances are prohibited and will not be allowed for use in this procurement without prior Government approval.

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

The Contractor Manpower Reporting Application (CMRA) is a Department of Defense Business Initiative Council (BIC) sponsored program to obtain better visibility of the contractor service workforce. This reporting requirement applies to all Army SBIR contracts.

Offerors are instructed to include an estimate for the cost of complying with CMRA as part of the Cost Volume for Phase I ($111,500 maximum), Phase I Option ($56,000 maximum), and Phase II ($1,100,000 maximum), under “CMRA Compliance” in Other Direct Costs. This is an estimated total cost (if any) that would be incurred to comply with the CMRA requirement. Only proposals that receive an award will be required to deliver CMRA reporting, i.e. if the proposal is selected and an award is made, the contract will include a deliverable for CMRA.

To date, there has been a wide range of estimated costs for CMRA. While most final negotiated costs have been minimal, there appears to be some higher cost estimates that can often be attributed to misunderstanding the requirement. The SBIR Program desires for the Government to pay a fair and reasonable price. This technical analysis is intended to help determine this fair and reasonable price for CMRA as it applies to SBIR contracts.

- The Office of the Assistant Secretary of the Army (Manpower & Reserve Affairs) operates and maintains the secure CMRA System. The CMRA Web site is located here: https://www.ecmra.mil/.

- The CMRA requirement consists of the following items, which are located within the contract document, the contractor’s existing cost accounting system (i.e. estimated direct labor hours,
estimated direct labor dollars), or obtained from the contracting officer representative:

1. Contract number, including task and delivery order number;
2. Contractor name, address, phone number, e-mail address, identity of contractor employee entering data;
3. Estimated direct labor hours (including sub-contractors);
4. Estimated direct labor dollars paid this reporting period (including sub-contractors);
5. Predominant Federal Service Code (FSC) reflecting services provided by contractor (and separate predominant FSC for each sub-contractor if different);
6. Organizational title associated with the Unit Identification Code (UIC) for the Army Requiring Activity (The Army Requiring Activity is responsible for providing the contractor with its UIC for the purposes of reporting this information);
7. Locations where contractor and sub-contractors perform the work (specified by zip code in the United States and nearest city, country, when in an overseas location, using standardized nomenclature provided on Web site);

- The reporting period will be the period of performance not to exceed 12 months ending September 30 of each government fiscal year and must be reported by 31 October of each calendar year.

- According to the required CMRA contract language, the contractor may use a direct XML data transfer to the Contractor Manpower Reporting System database server or fill in the fields on the Government Web site. The CMRA Web site also has a no-cost CMRA XML Converter Tool.

Given the small size of our SBIR contracts and companies, it is our opinion that the modification of contractor payroll systems for automatic XML data transfer is not in the best interest of the Government. CMRA is an annual reporting requirement that can be achieved through multiple means to include manual entry, MS Excel spreadsheet development, or use of the free Government XML converter tool. The annual reporting should take less than a few hours annually by an administrative level employee.

Depending on labor rates, we would expect the total annual cost for SBIR companies to not exceed $500.00 annually, or to be included in overhead rates.

**DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA) (FORMERLY KNOWN AS DISCRETIONARY TECHNICAL ASSISTANCE)**

In accordance with section 9(q) of the Small Business Act (15 U.S.C. 638(q)), the Army will provide technical assistance services to small businesses engaged in SBIR projects through a network of scientists and engineers engaged in a wide range of technologies. The objective of this effort is to increase Army SBIR technology transition and commercialization success thereby accelerating the fielding of capabilities to Soldiers and to benefit the nation through stimulated technological innovation, improved manufacturing capability, and increased competition, productivity, and economic growth.

The Army has stationed nine Technical Assistance Advocates (TAAs) across the Army to provide technical assistance to small businesses that have Phase I and Phase II projects with the participating organizations within their regions.

For more information go to: [https://www.armysbir.army.mil](https://www.armysbir.army.mil), then click the “SBIR” tab, and then click on Transition Assistance/Technical Assistance.
This technical and business assistance to SBIR awardees to assist in:

- Making better technical decisions on SBIR projects
- Solving technical problems that arise during SBIR projects;
- Minimizing technical risks associated with SBIR projects; and
- Developing and commercializing new commercial products and processes resulting from such projects including intellectual property protections.

Army may provide up to $5,000 of SBIR funds for the technical assistance described above for each Phase I award, and $10,000 per Phase II project to these vendors for direct support to SBIR awardees.

Alternatively, a SBIR firm may directly acquire the technical assistance services described above and not through the vendor selected by the Components. Firms must request this authority from the agency and clearly identify the need for assistance (purpose and objective of required assistance), provide details on the provider of the assistance (name and point of contact for performers) and why the proposed TABA providers are uniquely skilled to conduct the work (specific experience in providing the assistance proposed), and the cost of the required assistance (costs and hours proposed or other details on arrangement). This information must be included in the Explanatory Material section of the firm’s cost proposal specifically identified as “Discretionary Technical and Business Assistance.”

If the awardee demonstrates this requirement sufficiently, the agency shall permit the awardee to acquire such technical assistance itself, in an amount up to $5,000 for each Phase I award and $10,000 for each Phase II project, as an allowable cost of the SBIR award. The per year amount will be in addition to the award and is not subject to any profit or fee by the requesting (SBIR) firm and is inclusive of all indirect rates.

The TABA provider may not be the requesting firm, an affiliate of the requesting firm, an investor of the requesting firm, or a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g. research partner or research institution).

Failure to include the required information in the Phase I and/or Phase II proposal will result in the request for discretionary technical and business assistance being disapproved. Requests for TABA funding outside of the Phase I or Phase II proposal submission will not be considered. If the firm is approved for TABA from a source other than that provided by the agency, the firm may not be eligible for the technical assistance services normally provided by those organizations. Small business concerns that receive technical or business assistance as described in this section are required to submit a description of the assistance provided, and the benefits and results achieved. Contact the Army SBIR Program Office for any other considerations.

NOTE: The Small Business Administration (SBA) is currently developing regulations governing TABA. All regulatory guidance produced by SBA will apply to any SBIR contracts where TABA is utilized.

It should also be noted that if approved for discretionary technical and business assistance from an outside source, the firm will not be eligible for the Army’s Technical Assistance Advocate support. All details of the TABA agency and what services they will provide must
be listed in the technical proposal under “consultants”. The request for TABA must include details on what qualifies the TABA firm to provide the services that you are requesting, the firm name, a point of contact for the firm, and a web site for the firm. List all services that the firm will provide and why they are uniquely qualified to provide these services. The award of TABA funds is not automatic and must be approved by the Army SBIR Program Manager. The maximum TABA dollar amount that can be requested in a Phase I Army SBIR proposal is $5,000. The maximum TABA dollar amount that can be requested in a Phase II Army SBIR proposal is $5,000 per year (for a total of $10,000 for two years).

COMMERCIALIZATION READINESS PROGRAM (CRP)

The objective of the CRP effort is to increase Army SBIR technology transition and commercialization success and accelerate the fielding of capabilities to Soldiers. The CRP: 1) assesses and identifies SBIR projects and companies with high transition potential that meet high priority requirements; 2) matches SBIR companies to customers and facilitates collaboration; 3) facilitates detailed technology transition plans and agreements; 4) makes recommendations for additional funding for select SBIR projects that meet the criteria identified above; and 5) tracks metrics and measures results for the SBIR projects within the CRP.

Based on its assessment of the SBIR project’s potential for transition as described above, the Army utilizes a CRP investment fund of SBIR dollars targeted to enhance ongoing Phase II activities with expanded research, development, test and evaluation to accelerate transition and commercialization. The CRP investment fund must be expended according to all applicable SBIR policy on existing Phase II availability of matching funds, proposed transition strategies, and individual contracting arrangements.

NON-PROPRIETARY SUMMARY REPORTS

All award winners must submit a non-proprietary summary report at the end of their Phase I project and any subsequent Phase II project. The summary report is unclassified, non-sensitive and non-proprietary and should include:

• A summation of Phase I results
• A description of the technology being developed
• The anticipated DOD and/or non-DOD customer
• The plan to transition the SBIR developed technology to the customer
• The anticipated applications/benefits for government and/or private sector use
• An image depicting the developed technology

The non-proprietary summary report should not exceed 700 words, and is intended for public viewing on the Army SBIR/STTR Small Business area. This summary report is in addition to the required final technical report and should require minimal work because most of this information is required in the final technical report. The summary report shall be submitted in accordance with the format and instructions posted within the Army SBIR Small Business Portal at: https://sbir.army.mil/SmallBusiness/ and is due within 30 days of the contract end date.

ARMY SBIR PROGRAM COORDINATORS (PCs) for Army SBIR PHASE 20.2

<table>
<thead>
<tr>
<th>Participating Organizations</th>
<th>Program Coordinator</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army Futures Command (AFC)</td>
<td>Casey Perley</td>
<td>716-574-6311</td>
</tr>
<tr>
<td>Armaments Center (AC)</td>
<td>Ben Call</td>
<td>973-724-6275</td>
</tr>
<tr>
<td></td>
<td>Sheila Speroni</td>
<td>973-724-6935</td>
</tr>
<tr>
<td>Agency</td>
<td>Contact Name</td>
<td>Phone Number</td>
</tr>
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</tr>
<tr>
<td>Aviation and Missile Center (AvMC-A)</td>
<td>Dawn Gratz</td>
<td>256-842-3272</td>
</tr>
<tr>
<td>Aviation and Missile Center (AvMC-M)</td>
<td>Dawn Gratz</td>
<td>256-842-3272</td>
</tr>
<tr>
<td>Army Research Laboratory (ARL)</td>
<td>Francis Rush</td>
<td>919-549-4347</td>
</tr>
<tr>
<td>Army Test &amp; Evaluation Command (ATEC)</td>
<td>Kendra Raab</td>
<td>443-861-9344</td>
</tr>
<tr>
<td>Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR)</td>
<td>Lauren Marzocca</td>
<td>410-395-4665</td>
</tr>
<tr>
<td>Chemical Biological Center (CBC)</td>
<td>Martha Weeks</td>
<td>410-436-5391</td>
</tr>
<tr>
<td>Ground Vehicle Systems Center (GVSC)</td>
<td>George Pappageorge</td>
<td>586-282-4915</td>
</tr>
<tr>
<td>JPEO Armaments and Ammunition</td>
<td>Vincent Matrisciano</td>
<td>973-724-2765</td>
</tr>
<tr>
<td>JPEO Chemical, Biological, Radiological, and Nuclear Defense (CBRND)</td>
<td>Jacqueline Yearby-Wade</td>
<td>410-417-3596</td>
</tr>
<tr>
<td>Medical Research and Development Command (MRDC)</td>
<td>James Myers</td>
<td>301-619-7377</td>
</tr>
<tr>
<td>PEO Command, Control and Communications Tactical (PEO C3T)</td>
<td>Meisi Amaral</td>
<td>443-395-6725</td>
</tr>
<tr>
<td>PEO Intelligence, Electronic Warfare &amp; Sensors (PEO IEW&amp;S)</td>
<td>Michael Voit</td>
<td>443-861-7851</td>
</tr>
<tr>
<td>PEO Soldier</td>
<td>Mary Harwood</td>
<td>703-704-0211</td>
</tr>
<tr>
<td>Soldier Center</td>
<td>Cathy Polito</td>
<td>508-206-3497</td>
</tr>
<tr>
<td>Space and Missile Defense Command (SMDC)</td>
<td>Jason Calvert</td>
<td>256-955-5630</td>
</tr>
</tbody>
</table>

**ARMY SUBMISSION OF FINAL TECHNICAL REPORTS**

A final technical report is required for each project. Per DFARS clause 252.235-7011 (http://www.acq.osd.mil/dpap/dars/dfars/html/current/252235.htm#252.235-7011), each contractor shall (a) Submit two copies of the approved scientific or technical report delivered under the contract to the Defense Technical Information Center, Attn: DTIC-O, 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6208; (b) Include a completed Standard Form 298, Report Documentation Page, with each copy of the report; and (c) For submission of reports in other than paper copy, contact the Defense Technical Information Center or follow the instructions at https://discover.dtic.mil/.

**PROTEST PROCEDURES**

Refer to the DOD Program Announcement for procedures to protest the Broad Agency Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to:

Monroe Harden  
Acting Program Manager  
Army Small Business Innovation Research (SBIR)
These protests will then be forwarded to the appropriate contracting officer based on the sponsoring organization for the topic.

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

This is a Checklist of Army Requirements for your proposal. Please review the checklist to ensure that your proposal meets the Army SBIR requirements. You must also meet the general DOD requirements specified in the BAA. **Failure to meet these requirements will result in your proposal not being evaluated or considered for award.** Do not include this checklist with your proposal.

1. The proposal addresses a Phase I effort (up to $111,500 with up to a six-month duration) **AND** an optional effort (up to $56,000 for an up to four-month period to provide interim Phase II funding).

2. The proposal is limited to only **ONE** Army BAA topic.

3. The technical content of the proposal, including the Option, includes the items identified in Section 5.4 of the BAA.

4. SBIR Phase I Proposals have three (3) sections: Proposal Cover Sheet, Technical Volume, and Cost Volume. The Technical Volume .pdf document has a 20-page limit including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents [e.g., statements of work and resumes] and all attachments. However, offerors are instructed to NOT leave blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal submission as **THESE WILL COUNT AGAINST THE 20-PAGE LIMIT.** Any information that details work involved that should be in the technical volume but is inserted into other sections of the proposal will count against the page count. **ONLY** the electronically generated Cover Sheet and Cost Volume are excluded from the Technical Volume .pdf 20-page limit. Army Phase I proposals submitted with a Technical Volume .pdf document of over 20-pages will be deemed **NON-COMPLIANT** and will not be evaluated.

5. The Cost Volume has been completed and submitted for both the **Phase I and Phase I Option** and the costs are shown separately. The Army requires that small businesses complete the Cost Volume form on the DOD Submission site, versus submitting within the body of the uploaded proposal. The total cost should match the amount on the cover pages.

6. Requirement for Army Accounting for Contract Services, otherwise known as CMRA reporting is included in the Cost Volume (offerors are instructed to include an estimate for the cost of complying with CMRA).

7. If applicable, the Bio Hazard Material level has been identified in the Technical Volume.
8. If applicable, plan for research involving animal or human subjects, or requiring access to
government resources of any kind.

9. The Phase I Proposal describes the "vision" or "end-state" of the research and the most likely
strategy or path for transition of the SBIR project from research to an operational capability that
satisfies one or more Army operational or technical requirements in a new or existing system,
larger research program, or as a stand-alone product or service.

10. If applicable, Foreign Nationals are to be identified in the proposal.
<table>
<thead>
<tr>
<th>SBIR No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>A20-101</td>
<td>Continuous Flow Recrystallization of Energetic Nitramines</td>
</tr>
<tr>
<td>A20-102</td>
<td>Deep Neural Network Learning Based Tools for Embedded Systems Under Side Channel Attacks</td>
</tr>
<tr>
<td>A20-103</td>
<td>Beyond Li-Ion Batteries in Electric Vehicles (EV)</td>
</tr>
<tr>
<td>A20-104</td>
<td>Wireless Power transfer</td>
</tr>
<tr>
<td>A20-105</td>
<td>Direct Wall Shear Stress Measurement for Rotor Blades</td>
</tr>
<tr>
<td>A20-106</td>
<td>Electronically-Tunable, Low Loss Microwave Thin-film Ferroelectric Phase-Shifter</td>
</tr>
<tr>
<td>A20-107</td>
<td>Automated Imagery Annotation and Segmentation for Military Tactical Objects</td>
</tr>
<tr>
<td>A20-108</td>
<td>Multi-Solution Precision Location Determination System to be Operational in a Global Positioning System (GPS) Denied Environment for Static, Dynamic and Autonomous Systems under Test</td>
</tr>
<tr>
<td>A20-109</td>
<td>Environmentally Adaptive Free-Space Optical Communication</td>
</tr>
<tr>
<td>A20-110</td>
<td>Localized High Bandwidth Wireless Secure Mesh Network</td>
</tr>
<tr>
<td>A20-111</td>
<td>Non-Destructive Evaluation of Bonded Interface of Cold Spray Additive Repair</td>
</tr>
<tr>
<td>A20-112</td>
<td>Compact, High Performance Engines for Air Launched Effects UAS</td>
</tr>
<tr>
<td>A20-113</td>
<td>Optical Based Health Usage and Monitoring System (HUMS)</td>
</tr>
<tr>
<td>A20-114</td>
<td>3-D Microfabrication for In-Plane Optical MEMS Inertial Sensors</td>
</tr>
<tr>
<td>A20-115</td>
<td>Using Artificial Intelligence to Optimize Missile Sustainment Trade-offs</td>
</tr>
<tr>
<td>A20-116</td>
<td>Distributed Beamforming for Non-Developmental Waveforms</td>
</tr>
<tr>
<td>A20-117</td>
<td>Lens Antennas for Resilient Satellite Communications (SATCOM) on Ground Tactical Vehicles</td>
</tr>
<tr>
<td>A20-118</td>
<td>Novel, Low SWaP-C Unattended Ground Sensors for Relevant SA in A2AD Environments</td>
</tr>
<tr>
<td>A20-119</td>
<td>Efficient Near Field Charge Transfer Mediated Infrared Detectors</td>
</tr>
<tr>
<td>A20-120</td>
<td>Very Small Pixel Uncooled Longwave Read-Out Integrated Circuit for Enhanced Sensor SWAP and Range Performance</td>
</tr>
<tr>
<td>A20-121</td>
<td>Polarimetric Modeling and Visualization</td>
</tr>
<tr>
<td>A20-122</td>
<td>Infrared Transparent Adhesive</td>
</tr>
<tr>
<td>A20-123</td>
<td>CdZnTe Substrate Screening</td>
</tr>
<tr>
<td>A20-124</td>
<td>No burden / low burden biological air sampler</td>
</tr>
<tr>
<td>A20-125</td>
<td>Indicator Chemicals for In-theater Inkjet Assay Production</td>
</tr>
<tr>
<td>A20-126</td>
<td>Programmable AC/DC Lithium-ion Battery for High-voltage Applications</td>
</tr>
<tr>
<td>A20-127</td>
<td>Retractable Gunner Restraints</td>
</tr>
<tr>
<td>A20-128</td>
<td>Advanced Heavy-Duty Diesel Engine Piston</td>
</tr>
<tr>
<td>A20-129</td>
<td>Rapid Terrain/Map Generation for Robotic and Autonomous Vehicle Simulations</td>
</tr>
<tr>
<td>A20-130</td>
<td>Mobile Medic Interior Seating</td>
</tr>
<tr>
<td>A20-131</td>
<td>Radio Network Model Plugin for Unreal Engine Vehicle Simulation</td>
</tr>
<tr>
<td>A20-132</td>
<td>Lightweight Robotic Mule</td>
</tr>
<tr>
<td>A20-133</td>
<td>Innovative Technologies for Precision Timing of Onboard Munition Navigation Systems</td>
</tr>
<tr>
<td>A20-134</td>
<td>Innovative and Intelligent Standoff Detection Algorithm</td>
</tr>
<tr>
<td>A20-135</td>
<td>Low-Cost Gamma Dose Rate Technology for Military Operations</td>
</tr>
<tr>
<td>A20-136</td>
<td>Automated Encounter Documentation and Data Driven Decision Support Systems</td>
</tr>
<tr>
<td>A20-137</td>
<td>To Develop and Demonstrate an Advanced Combat Wound Care Technology that Prevents Sepsis from Infected Traumatized Tissue</td>
</tr>
<tr>
<td>A20-138</td>
<td>Distributed Coded Computing for Content Management at the Tactical Edge</td>
</tr>
<tr>
<td>A20-139</td>
<td>Software Defined Everything (SDx) and 5G/6G Cellular Design Prototype for Tactical Radios</td>
</tr>
<tr>
<td>A20-140</td>
<td>High Performance Optical Fibers for 100-Watts Infrared Lasers</td>
</tr>
<tr>
<td>A20-141</td>
<td>C4ISR/EW Modular Open Suite of Standards (CMOSS)-based Common Data Link (CDL) Radio Transceiver</td>
</tr>
<tr>
<td>A20-142</td>
<td>Federated Intelligence, Surveillance, Reconnaissance (ISR) Collection Management Using Machine Learning (ML)</td>
</tr>
<tr>
<td>A20-143</td>
<td>A Novel Non-Uniformity Correction (NUC) Approach for Night Vision Cameras</td>
</tr>
<tr>
<td>A20-144</td>
<td>Aerostat Payload Protection (APP) System</td>
</tr>
<tr>
<td>A20-145</td>
<td>Active Noise Reduction HGU-56P Aviator Helmet</td>
</tr>
<tr>
<td>A20-146</td>
<td>Low Voltage Cable Reflectometer Built in Test Module</td>
</tr>
<tr>
<td>A20-147</td>
<td>Light-weight Internal-combustion High-power, Transformative, Novel, Individual New Generator (LIGHTNING)</td>
</tr>
<tr>
<td>A20-148</td>
<td>Flight Test Execution Team Pre-Mission Training Tool</td>
</tr>
<tr>
<td>A20-149</td>
<td>High-Power Tapered Amplifier Laser Diode Array With Active Phase Control Feedback Loop for Future High Energy Laser Weapons</td>
</tr>
<tr>
<td>A20-150</td>
<td>Photonic Crystal Surface Emitting Semiconductor Laser</td>
</tr>
</tbody>
</table>
A20-101 TITLE: Continuous Flow Recrystallization of Energetic Nitramines

RT&L FOCUS AREA(S): General Warfighting
TECHNOLOGY AREA(S): Materials

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Design, develop and demonstrate a continuous process for direct recrystallization of energetic materials.

DESCRIPTION: Energetic materials are dual-use materials used in private industry, recreational sport, and military applications. Energetic materials are extremely dangerous to handle. Unfortunately the manufacturing processes used today are decades-old using antiquated equipment. This has resulted in catastrophic events leading to injury and death over the years. The design and engineering capabilities available today, along with innovative technologies that were not available decades ago, offer a unique opportunity for the implementation of safer and sustainable manufacturing processes for energetics. The main steps include the reaction, filtration, and recrystallization while extraction and distillation processes are also utilized depending on the material. These steps typically include an operator interfacing with sometimes dangerous intermediates and products. The main reaction can be done in batch or continuous reactors. Development of continuous flow synthetic approaches applied to energetic materials have demonstrated several advantages including reduced waste, material in process, process control and product quality. In order to fully realize the potential of continuous flow synthesis it needs to be paired with complementary continuous flow technologies including filtration, recrystallization, extraction, and distillation. Continuous flow recrystallization presents one of the largest challenges and opportunities in continuous flow preparation of nitramines including RDX and HMX. The pharmaceutical industry has demonstrated use of continuous flow recrystallization to result in improved purity, particle size control and particle size distribution. This topic desires continuous flow recrystallization strategies for direct recrystallization to each of the RDX/HMX class sizes (eliminating grinding steps) with tighter particle size, greater process control and improved process waste profiles while retaining the desired polymorph for each.

PHASE I: The small business will investigate innovative strategies for lab-scale continuous flow recrystallization of RDX and HMX with tunable particle size distribution within the range specified for various class sizes and their respective desired polymorph. This lab-scale work will develop models based off of experimental work to better understand process kinetics and viability. The phase I output will be a prototype process for energetic material recrystallization that results in a tunable system for the direct production of Class 1-5 nitramines with their desired polymorph. This prototype process will result in a 20% tighter particle size distribution, eliminated operator exposure and developed strategies for inline process monitoring. While initial process development may be on surrogate compounds, the final prototype and evaluation must be on either RDX or HMX. A Phase II effort must be on the energetic materials.

PHASE II: Development and demonstration of a pilot scale process for continuous nitramine recrystallization. The process models generated in Phase I should be validated, optimized for
affordability and robustness, and developed into a physical pilot process. This pilot scale process should produce final product at a rate of at least 1 g/min. The demonstration should exhibit polymorph and particle size control to each of the class sizes and be transition-able to manufacturing environments. It should show reduced particle size distribution, operator exposure, hazardous waste generation, and greater process control. A 20 g sample of each class size must be shipped to CCDC-Armaments Center for further evaluation of product quality. Phase II will conclude with a full process design and transition plan.

PHASE III DUAL USE APPLICATIONS: The process developed in Phase II should be scalable to production capacity. This capability will allow greater flexibility in meeting warfighter needs for nitramine-based end items in times of high demand with lower infrastructure costs than large scale batch recrystallization process equipment. It will also result in greater control of nitramine explosive properties (due to tighter control of particle size distribution) for improved end item reliability.

REFERENCES:

KEYWORDS: Continuous Flow, Recrystallization, Nitramines, Process Analytical Technology
A20-102

TITLE: Deep Neural Network Learning Based Tools for Embedded Systems Under Side Channel Attacks

RT&L FOCUS AREA(S): Cybersecurity, AI/ML
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The Army Combat Capabilities Development Command (CCDC) Armament Center leads the Army for cyber secured weapons, sensors and systems. CCDC sponsored a series of new generations of embedded systems and communication systems development for weapons. The current efforts focus on the capabilities of using deep learning technologies to enhance both hardware and software in relevant dense urban environments. One key aspect of these efforts is to enhance weapons to defend against side-channel attacks (SCAs).

DESCRIPTION: The current efforts focus on the capabilities of using deep learning technologies to enhance both hardware and software in relevant dense urban environments. One key aspect of these efforts is to enhance weapons to defend against cyber attacks; AI/ML techniques to identify and counter SCAs are of particular interest under this SBIR [1-9].

PHASE I: Government expects that basic investigations can be accomplished during Phase I. While deep learning neural network outperformed existing approaches in SCAs, there are several standing questions that require further investigations. 1) What are the meanings of the activation functions and weights correspondent to the keys and architectures under SCAs? 2) How to extract the features or group of features correspondent to the different components in one system architecture? 3) How to assemble/refine a neural network if we have trained neural network models for general components (i.e. different type of memory architectures)? To fully understand and utilize this powerful technique, the offeror should:

- Investigate the anatomy of the neural network.
- Identify the neural network models for basic components in architectures.
- Build and refine deep learning neural network using basic neural network models.
- Compare TA, ML-based approaches with the proposed deep learning neural network.

It is anticipated that the Phase I study will be unclassified.

PHASE II: Software/Hardware Implementations: during this phase, the Government expects the models/software modules developed in Phase I to be integrated into the existing sensors, weapons, and communication systems. We also expect the offeror to investigate plug-and-play hardware implementation that can upload the existing deep learning software. As an integrated component, this new hardware shall be inserted onto the existing sensors, weapons and communication system to perform real time cybersecurity.

It is anticipated that this Phase will be executed at the SECRET level.
PHASE III DUAL USE APPLICATIONS: The government expect the offeror to provide software products based on deep learning SCAs, and hardware products with our deep learning software upload to perform real time guardiances in cyber security for existing CCDC systems. These products will have military engineer/soldier friendly interfaces to assist training and reconfigurations thereof.

REFERENCES:

KEYWORDS: Deep Neural Network, Artificial Intelligence, Machine Learning, Hardware, Software
TITLE: Beyond Li-Ion Batteries in Electric Vehicles (EV)

RT&L FOCUS AREA(S): General Warfighting
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: Develop the next generation energy storage device for future U.S. Army vehicle platforms, to include hybrids and fully electric vehicles.

DESCRIPTION: In the next generation combat vehicle power generation, energy storage, energy recharge, and energy distribution capabilities will be critically important. Full or partial electrification of a vehicle will enable significant improvements in offensive capabilities, agility & maneuverability, extended operational duration, on-board and exportable power, and reduced signatures for vehicles and mobility systems.

To support the creation of a Highly Electrified Platform (HEP), there is a need for new energy storage technologies. The HEP will have extremely high energy demands that will require the vehicle to store several Megawatts of energy to ensure full system functionality in all operational environments across the range of military operations, from training to counter-insurgency to full scale war. This program of effort seeks to identify technology that:

• Provides, at a minimum, a specific energy of 400 watts per kilogram;
• Is capable of recharge at a rate of >2C; and,
• Maintains the same safety and reliability standards as today’s Li-Ion batteries.

Awards made under this topic will be for a maximum of $50,000 with a three-month period of performance. The Phase I Option period amounts and durations are not changed.

PHASE I: Determine technical feasibility of battery reaching above standards. Develop preliminary storage technology design, model key elements, and identify subcomponents that demonstrate clear path towards meeting requisite minimum standards with a robust safety profile. Phase I deliverables include a design review including expected device performance, and a final report including Phase II plans.

Awardees selected for this topic will receive a maximum of $50,000 and have a period of performance of three months. Awardees also have the ability to voluntarily participate in an Army Application Lab cohort program. Companies will kick off the SBIR on location, meeting with end users, getting access to relevant equipment, and talking with key stakeholders. Virtual office hours, to be taken advantage of as desired, will be held weekly throughout the 12 week period of performance. Midway through there will be a virtual touch point with stakeholders to answer questions that may have arisen during the company’s concept design week preparations. The final week of the program will involve an in-person outbrief to key stakeholders and AAL. While the cohort programming will be provided free of charge, participating companies must travel and participate out of company internal operating budgets. Proposers that plan to participate in the cohort (if awarded a Phase I) are encouraged to include travel costs for two cohort trips, within the continental US, of 2-3 days each for the in person programming. Details will be provided to awardees under this topic at Phase I award.

PHASE II: Develop a prototype of the battery to the specifications determined in Phase I design study. Conduct a formal risk assessment of the cell and thermal monitoring solutions for the transportation, storage and use of the battery in operational environments. Phase II deliverables include delivery of a prototype for further Army evaluation, as well as quarterly and final reports detailing design and performance analysis of the prototype.
Awardee(s) of this topic will have the ability to voluntarily participate in quarterly soldier touch-points, a 1-2 day trip within the continental US. Touch point will be provided free of charge, however participating companies must travel and participate out of company internal operating budgets. Soldier touch point details will be provided to awardee(s) under this topic at Phase II award.

PHASE III DUAL USE APPLICATIONS: Develop a manufacturing ready product design, capable of integration with at least one Army vehicle platform, and demonstrate technology integration as part of a vehicle system. Low rate production will occur as required. Potential commercial uses include electric commercial vehicles, trucks, and trains; and mass transportation infrastructure.

REFERENCES:

KEYWORDS: Battery; Energy Storage, Next Generation Battery; Beyond Li-Ion
TITLE: Wireless Power transfer

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: Develop methods for high efficiency, long range wireless power transfer

DESCRIPTION: The Army is increasingly relying on expeditionary electric power --from soldier borne equipment and novel UAS platforms, to life support and communication systems in command posts, and the desire to electrify combat vehicles. The Army’s transition to greater reliance on electric power, and the increased likelihood of fighting dispersed on the future battlefield requires an overhaul of our electricity generating, transmission, and storage process.

In particular, innovations in wireless recharging capabilities for the growing commercial electric vehicle market has sparked interest in the way the Army will conduct future resupply convoys. Currently battlefield electricity is powered by diesel powered generators. Studies show that 52% of all US military casualties in Iraq and Afghanistan occurred during attacks on land based resupply missions. Additionally, dispersed elements may not be able to be resupply by traditional convoys in combat. While concurrent efforts to develop unmanned resupply vehicles are also underway, the Army is hoping to leverage wireless power transfer technology to significantly reduce the need for fuel deliveries.

The Army requires long range wireless power transfer that could include (but is not limited to):

- continuous wireless power transfer from point of generation to end user at a distance of greater than 3.5 meters
- variable transfer capacity to fulfill requirements at multiple echelons
- non-interference transfer methods which are secure from enemy interference
- ability to transfer power between moving transmitters and/or receivers
- has a robust safety profile

PHASE I: Provide proof of concept for wireless power transfer technology and capability estimates. This should also highlight any related safety risks at higher transmission capacities if any exist. Proposals are evaluated based on scalability, transfer capacity, modularity, and usability, that demonstrate clear path towards meeting requisite minimum standards with a robust safety profile. Phase I deliverables include a design review, and a final report including Phase II plans. Solutions will be chosen based on a holistic constellation of features including distance of transmission and safety profile especially in areas with personnel, electronic systems and munitions.

Awardee(s) of this topic will have the ability to voluntarily participate in quarterly soldier touch-points, a 1-2 day trip within the continental US. Touch point will be provided free of charge, however participating companies must travel and participate out of the company's internal operating budgets. Soldier touch point details will be provided to awardee(s) under this topic at Phase I award.

PHASE II: Develop and manufacture a functional prototype of wireless power transfer technology. Prototypes are required to have safety testing completed and available to highlight risks and mitigation techniques. Proposals are evaluated based on scalability, transfer capacity, risks of operation, and usability. Solutions will be chosen based on the same constellation of features as in Phase I, in addition to portability.

Awardee(s) of this topic will have the ability to voluntarily participate in quarterly soldier touch-points, a 1-2 day trip within the continental US. Touch point will be provided free of charge to participating

ARMY 20
companies, however companies must travel and participate out of the company's internal operating budgets. Soldier touch point details will be provided to awardee(s) under this topic at Phase II award.

PHASE III DUAL USE APPLICATIONS: Perform power transfer operations with scenarios consistent with military operating environment and tactics. Potential commercialization use cases include wireless area charging of personal electronics devices, powering electronics during movement, and wireless power grids.

REFERENCES:

KEYWORDS: wireless power transfer; WPT; recharge; wireless; electricity transmission
TITLE: Direct Wall Shear Stress Measurement for Rotor Blades

OBJECTIVE: Directly measure mean and fluctuating shear stress on a rotor blade.

DESCRIPTION: Aerodynamic loads on rotor blades are driven in large part by the dynamics of the boundary layer. Each point of the blade undergoes large variations in aerodynamic regimes throughout its operation; including tangential speed variations along the span, variation of both mean and fluctuating angles of attack as a result of the setting of collective and cyclic controls, as well as variation in the magnitude of the oncoming flow speed throughout the rotation in forward flight. All of these factors influence the behavior of the boundary layer and ultimately lead to the overall aerodynamic performance of a vertical lift vehicle platform.

Numerical calculation of these loads from high-fidelity computation fluid dynamics models is possible, but validation of sufficiently complex models is difficult without the ability to directly measure surface pressure and shear stress at various locations on the rotor blade system. Direct point-wise sensing of these quantities would permit model validation, as well as insight into the boundary layer physics. Many boundary layer models are developed from investigations that do not include the full complexity of the actual flows (i.e. 2D vs 3D, swept wing vs rotation, Mach and Reynolds number mismatches, etc.) and thus suffer from empiricism and questionable applicability to the vehicle system. Capturing the behavior of the boundary layer subject to all the relevant physical mechanisms has potential to significantly advance fundamental understanding of the unsteady boundary layer physics, which in turn will permit more advanced vehicle/rotor system designs.

Historically, hot-film anemometry and oil-film interferometry have been used as wall-shear stress measurements, but suffer from directionality, bandwidth, and the need to infer wall-shear stress behavior rather than sense it directly. A sensor capable of conducting these measurements will need to meet several challenges associated with operation in this domain: the sensor must 1) be able to be installed in rotor blades with realistic geometries, to include thin/narrow airfoils, 2) operate reliably while undergoing dynamic motion (e.g. pitch, rotation), 3) have sufficient bandwidth, dynamic range, directional sensitivity, and spatial resolution to capture relevant boundary layer physics (both mean and fluctuating quantities), and 4) provide a means for accurate readout during rotational operation of the rotor blade system. Current MEMS-based or photonics-based sensing modalities, while capable of direct wall-shear stress measurement in a steady environment, need additional development to address all of the above-mentioned challenges.

PHASE I: Perform an analysis of the required sensor performance metrics for implementation on a current full-scale vertical lift vehicle platform. The analysis should consider the challenges listed in the description, considering the boundary layer physics (both mean and fluctuating quantities) on a rotor blade for a full-scale vertical-lift vehicle, the effect of dynamic motion (e.g. pitch and rotation), methodologies for data readout from the rotating environment, and form factors capable of being integrated on realistic geometries without necessitating compromise of the rotor blade structure.

Provide a conceptual design of a wall shear stress sensor that addresses the operational environment; including form factor, acceleration compensation, readout connectivity, and overall integration with the rotor blade system.

Phase I will conclude with a viable sensor design for development in Phase II.
PHASE II: Develop a working shear stress sensor prototype that meets the identified requirements and demonstrate operation in a relevant environment. This phase should demonstrate and characterize all aspects of the measurement system, to include: 1) sensing element, 2) transducer, 3) measurement signal routing, and 4) all necessary electronics for useful signal output, such that the sensor can be directly utilized in conjunction with typical COTS data acquisition systems.

PHASE III DUAL USE APPLICATIONS: Refine prototype designed in Phase II for technology transfer for commercial and military applications, to include university laboratories, DoD laboratories and research centers, NASA vertical-lift research efforts and helicopter and wind-turbine manufacturers. Successful implementation of this measurement technology will enable future design and performance analysis of vertical lift systems capable of increased performance (range, endurance, efficiency, safety, etc.).

REFERENCES:

KEYWORDS: wall shear stress, rotor blade, vertical lift, boundary layer physics
PHASE I: Ferroelectric material with intrinsic material $Q$'s over 1000 is within the current state-of-the-art [4-6]. Phase I of this topic will require the demonstration that the proposing company can grow and characterize high quality FE thin films with high intrinsic material $Q$ and electronic tunability of 10:1 within an operating range of +/- 100 V and within the frequency range of 1-12 GHz. Design a FE phase shifter device structure using this material and show, by analysis or simulation, its feasibility for an electronically tuned phase shifter capable of continuous phase shift of 360 degrees in the frequency range of 1-12 GHz with low insertion loss (<6 dB) and tuning speeds of 0.5 microseconds. Develop and maintain contact with ARL (Army Research Laboratory) researchers for advice on materials measurement and application. Provide materials sample to ARL researchers for confirmation.

ARMY 24
PHASE II: Develop a synergistic model that couples predictive materials design with phase shifter design and performance. Characterize the frequency dependent dielectric properties of the FE thin films, including permittivity, tunability, and dielectric loss, using basic test devices. Establish and demonstrate the low loss integration of the thin film FE material with the device structure and optimize the insertion loss and tunability. If the FE material will be metallized, demonstrate Q’s greater than 200 in MIM structures with 10:1 tunability with +/- 100 V tuning voltage. If the FE material will be used in a different device structure, demonstrate the low loss performance over the same tuning range. Demonstrate a phase shifter device capable of the metrics outlined above. Optimize the coupled device and FE material insertion loss and tunability, and a flat differential phase shift over the frequency range. Fully fabricate phase shifter prototypes ready for evaluation. Electrically characterize the phase shifter properties including S11 and S21 measurements over the frequency range. Deliver sample devices to the designated government laboratory for assessment and validation. Optimize the materials and device fabrication process for commercial scalability, considering the use of buffer layer or virtual substrate techniques for integration. Make contacts with communications and radar systems development offices such as CCDC C5ISR Center (Combat Capabilities Development Command Communications-Electronics Research, Development and Engineering Center) and industry systems providers to determine specific design parameters for a customer base. Develop a full commercialization plan to exploit these opportunities.

PHASE III DUAL USE APPLICATIONS: Develop components and circuits capable of meeting selected customer specifications for phase shifter circuits for applications in tactical radio and commercial wireless system handsets and radio systems. Describe specific military applications where the new technology will enable solution of specific problems. Provide a firm technology transition pathway for their developments (for example establish a production line for the fabrication of these circuits and components, produce the individual components for sale, or establish a licensing relationship with a company with a production capability). The path to commercialization is expected to first address radar and communications requirements for military and commercial systems, but is expected to expand into other wireless and electronic systems applications. Recommended transition paths are for mobile vehicular radio links via the Program Executive Office Command and Control or radars for the Program Executive Office Intelligence, Electronic Warfare, and Sensors. Significantly lowering the cost of the phased array antenna will bring the capability to use phased array systems to a much wider variety of military platforms, and therefore a greater market base. Commercial radio links and radars would be of interest to companies such as Lockheed Martin, Boeing, or Raytheon. Emerging 5G market will be explored for opportunities for further commercialization.

REFERENCES:

KEYWORDS: phase shifter, electronically tunable, ferroelectric, thin film
TITLE: Automated Imagery Annotation and Segmentation for Military Tactical Objects

RT&L FOCUS AREA(S): Network, AI/ML
TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop and demonstrate a capability to automatically generate image annotation and segmentation data from Full Motion Video (FMV) of complex military tactical objects.

DESCRIPTION: There is a growing need to expedite the manual image annotation and segmentation process that precedes the development of algorithm development for vision-based sensor systems. Annotation (defining regions within an image) and segmentation (labeling pixels within an image) are data prerequisites to the development of computer vision-aided Automatic Target Recognition (ATR) algorithms, Machine Learning (ML), and Artificial Intelligence (AI) capabilities. Prior to the development of algorithms associated with ATR/ML/AI, FMV with new content of interest must be meticulously annotated and segmented by a human-in-the-loop so that the algorithms “understand” the FMV content. This is an extremely expensive, labor intensive task which is recognized as the single greatest bottleneck hindering algorithm development, ML, and AI. This effort will significantly reduce the level-of-effort required to manually annotate and segment tactically relevant information in FMV.

Tactical military objects offer unique, additional challenges that commercial annotation and segmentation products do not address. Commercial applications of computer vision-based autonomous systems designed for object detection are focused on autonomous vehicle technology, which emphasizes a totally different application space. For example, most tactical objects are designed to blend into the surrounding environment, void of textual content, objects of interest appear in unexpected location/positions, and dissimilar in appearance to the objects which commercial products tend to focus on (i.e. text, persons, cars).

Many advances have occurred in the area of automated annotation and segmentation of FMV for the commercial industry due to requirements of self-driving automobiles. While similarities exist, annotation and segmentation for military tactical objects emphasize a different application space. Although the application space is different, the advances in state-of-the-art deep learning models for optical flow computation and semantic segmentation in the commercial sector suggests a strong possibility of success in performing autonomous annotation and segmentation with sufficient accuracy (>95%) for military applications.

Typical annotation by an individual varies, but statistical studies indicate an average annotation time of 35 seconds per image for a given annotator. With the use of existing semi-automated tools and various methods, an average time of approximately 7 seconds is achievable with an accuracy of no greater than 70%, which is too low for military applications.

The optimal solution must be able to automatically analyze high-resolution FMV of military tactical objects and accurately produce XML metadata files that accurately annotate and segment the object’s tactically relevant “features” which are used by ATR/ML/AIs algorithms operating on similar content of interest. Annotation / segmentation must support algorithms designed to confidently and consistently report attributes such as object classification, identification, and tactically relevant “features” such as the number of wheels, dimensions, track indicators, barrel length, antenna type/configuration, armament, camouflage, and other object attributes discernable by Electro-optical and Infrared imaging sensors. The capability must output XML data products which are consumable in many system architectures. The delivered capability should offer the user options to tailor the focus system’s processing to specific attributes sought by the algorithm developer. It may be acceptable to preload the system with known
attributes of the objects within the FMV file and the geospatial environment which the FMV was captured.

Prioritized requirements for this capability include: 1) autonomously annotate and segment military tactical objects within FMV files, 2) extract target features from the object which enable ATR/ML/AI development, and 3) minimize the amount of time a person must invest to the pre/post process the FMV.

PHASE I: The research effort shall explore technologies for automated image segmentation and annotation. Investigate and determine the characteristics of the solution that meets the requirements. Using a standard data set (Pascal VOC) of 10,000 images, create a semiautomated solution that meets the requirements: 1) 6 second average annotation time per image; 2) 95 percent average annotation accuracy across entire 10,000 image dataset; 3) resulting annotated images must enable ATR/ML/AI engines to identify “cropped” objects with 5% or less non-object content; 4) segmentation objective must indicate specified target feature 95% of the time that the attributes are resident in any image frame of FMV; 5) output data products in XML format metadata files that accurately annotate and segment the object’s tactically relevant “features” which are used by ATR/ML/AIs algorithms. The primary deliverable is a detailed design and analysis documentation demonstrating a proposed system that meets the requirements and a demonstration of the research including software components, capabilities, and methods to be used to achieve the solution. Develop documentation for a proposal for the solution for Phase II consideration.

PHASE II: Phase II research should demonstrate the solution required to enable the capability. The focus of the demonstration must be the solution’s ability to achieve the requirements specified in Phase I using three different standard datasets, each with a minimum of 10,000 images. Additionally, research to design, develop, and integrate a fully automated (no human-in-the-loop) solution to meet the requirements specified in Phase I. Demonstrate the fully automated solution (no human-in-the-loop) that meets the requirements using three different standard datasets, each with a minimum of 10,000 images.

Deliver 1 semi-automated and 1 fully automated prototype to ARL for testing to validate that the fully automated system is capable of meeting the specified performance, including each of the primary requirements, updated documentation to specify all hardware, software, and firmware subsystems that defines the entire solution. The system must be able to meet all system performance specifications.

PHASE III DUAL USE APPLICATIONS: Further develop the platform into a fully functional product that can reliably perform fully automated (no human-in-the-loop) image annotation and segmentation, output data in the prescribed format, and provide the user effective options to precondition the system to produce a tailored output. In Phase III, given 10,000 images from FMV of five different tactical targets, the Phase III system must be able to collectively demonstrate the requirements specified in Phase II, with a repeatability rate of 99% or better when exposed to different FMV image data sets of the same target. Commercial applications include the medical field for accurately screening patients for diseases such as cancer.

REFERENCES:

KEYWORDS: Image annotation and segmentation, machine vision, ATR, machine learning, artificial intelligence
TITLE: Multi-Solution Precision Location Determination System to be Operational in a Global Positioning System (GPS) Denied Environment for Static, Dynamic and Autonomous Systems under Test

RT&L FOCUS AREA(S): Cybersecurity, network
TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Design and create a system that can provide precision location information on static, dynamic and autonomous systems under test within a GPS denied environment.

DESCRIPTION: Threats to GPS signals availability has created new GPS receiver designs with are intended to operate in a GPS denied environment to provide both timing and precise location data to the user equipment or as a part of a larger system relying on these data feeds for systems functionality. As the requirements to test GPS receivers designed to operate in a GPS denied environment increase, there is a need to have precision location data of the system under test to be used to determine effectiveness of the new GPS receiver designs in these environments. As most of the position location systems in use rely on using the GPS signals in space for determination of their position, there is a need to have a means to provide the precise location of the GPS systems under test on static, dynamic and autonomous moving platforms without having to rely on the GPS signals, using other means to determine precision location data on static and moving platforms. This effort will develop a capability that could be used in testing to ensure that true location data can be used as a baseline to the new GPS receiver systems in determining their ability to correctly determine location within the GPS denied environment.

PHASE I: Develop a method of determining precision location data not reliant on using the GPS signals as a means for determination. The method will be able to be used in a test range environment that allows for position location updates at a one second interval and able to be integrated on a dynamic moving platform and autonomous moving platforms. Accuracy of the data solution should be equal to that of the position of a GPS receiver operating in a non-denied environment with full view of the GPS satellite constellation view.

PHASE II: Develop and demonstrate a prototype system operating in a GPS enabled environment and after successful demonstration, operate within a GPS denied environment with dynamic platforms and varied operating conditions.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian Command, Control, Communication and Intelligence (C3I) applications where precision location determination is required in areas of potential GPS signals denial, or as a supplement to GPS signals determined location data. The prototype configuration will be matured into a stand-alone, portable, system that is deployable and operable by test support personnel and demonstrated in a realistic field-test environment.

REFERENCES:
4. N/A
KEYWORDS: precision location determination, GPS denied environment, autonomous, moving platforms, testing.
TITLE: Environmentally Adaptive Free-Space Optical Communication

RT&L FOCUS AREA(S): network
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an approach to free-space optical communication (FSOC) that adapts to environmental conditions based on an estimate of current conditions impacting optical propagation (optical turbulence, extinction, jitter, etc.), via direct or indirect measurements, to improve communication performance.

DESCRIPTION: The military and commercial sectors have increasing needs for high-speed data transmission over long atmospheric paths. Due to their high directivity and high oscillation frequency, optical beams can transmit data over free space much faster than radio and microwave frequencies. Over the past couple of decades, there have been significant advances in optical source and receiver technology to reduce source power requirements, extend link distances, and increase link margins. Unfortunately, optical beams are much more susceptible to weather, clouds, turbulent fluctuations in the air’s refractive index, and spatial motion in transmit and receive platforms [1].

Still, a FSOC system on a mobile platform will likely need to operate over a very broad range of conditions, e.g., link distance, geographic location, and time of day. In the past few years, there have been significant improvements in modeling environmental factors that affect the transmission of optical beams through the open air. This is especially true for the lower atmosphere in the boundary layer [2,3]. If environmental information, such as GPS coordinates, time of day, and meteorological measurements are available in real time, and the models can calculate optical turbulence parameters quickly, the FSOC system could adapt itself to improve its performance. This would provide additional resilience beyond that provided by the margin of the link power budget without resorting to a secondary radio frequency (RF) channel.

The end goal of this SBIR topic is to develop (Phase I and II) and demonstrate (Phase III) an approach to adapting a FSOC only system within engineering constraints combined with sufficient environmental modeling for a diverse range of geographic sites, times of day, and link paths in the atmosphere. A Phase I effort will develop a concept for adapting a FSOC system and identify the required model and input data. A Phase II effort would involve developing a fast modeling code and demonstrating the FSOC adaptation concept in computer simulation. Conducting laboratory or outdoor field experiments would be a plus. A Phase III effort would demonstrate the full prototype adaptive FSOC system in the field at multiple sites in day and night times.

PHASE I: Devise an initial approach to adapting a FSOC system (beam properties, wavelength, encoding, etc.). Identify a set of inputs needed to drive that adaptation and likely sources of the basic data (sensors, databases, etc.). This step will ensure that the developed approach is ready for a Phase II effort.
PHASE II: Using the results from Phase I, with validation and uncertainty estimates for phase II, finalize the FSOC design and demonstrate its use in extensive computer simulations. The simulations should be done with an emphasis on determining which parameters and inputs contribute most to improving system performance. Conduct relevant experiments, either in a laboratory or the open air, to validate correlation of computer simulations with empirical results. The correlation must include an estimate of uncertainty of the computer simulations for a variety of parameters and inputs. This step shall ensure that the developed approach is ready for a Phase III effort. In this manner, the FSOC prototype will provide initial validation of an optical communications performance.

PHASE III DUAL USE APPLICATIONS: Military application: Demonstrating the developed approach in a field environment at distances greater than 1 km with a moving transmitter or receiver platform. This step shall ensure that the developed approach is ready for realistic operations. The FSOC prototype will be used in field conditions to provide effectiveness predictions of optical communications in a variety of combat environmental conditions.

Commercial Application: The successfully demonstrated FSOC approach could be applied to commercial aircraft, vehicles, and trains where high speed data transmission is required.

REFERENCES:

KEYWORDS: communication, lasers, meteorology, sensing
TITLE: Localized High Bandwidth Wireless Secure Mesh Network

RT&L FOCUS AREA(S): network
TECHNOLOGY AREA(S): Electronics

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OBJECTIVE: Provide an equipment centralized network solution that allows the digitization of RF spectrum into packetized IF to transport massive amounts of data.

DESCRIPTION: The RF spectrum from any antenna source on the White Sands Missile Range shall be digitized, transported to, and faithfully reconstructed at a centralized operations facility. The architecture must allow for the ability to move ground modems and processing equipment away from antennas so that they can be shared among multiple antennas, allowing the ability for multiple grounds sites to access and work with the same data.

PHASE I: End product for Phase I should be a fully vetted design of a High Bandwidth Wireless Secure Mesh Network with an architecture that allows for the ability to move ground modems and processing equipment away from antennas so that they can be shared among multiple antennas, allowing the ability for multiple grounds sites to access and work with the same data.

PHASE II: End product for Phase II shall be a prototype that interfaces existing COTS technologies which generates a concentrated invisible beam of light which has properties similar to a laser but with incoherent output (safer and better for distance) than a laser. The beam does not spread out like typical light but stays in a close formation like a laser with billions of pulses of light in a single second which are detectable at high bandwidths greater than 10Gbps. Adding additional wavelengths to the beam is easy due to the design flexibility which will increase the bandwidth to 40Gbps and possibly over 100Gbps on a single beam. Multiple detectors filter out and separate the channels.

PHASE III DUAL USE APPLICATIONS: Fully automated networking system solution allowing for digitization of RF spectrum into packetized IF, subsequently allowing the secure transportation of massive amounts of data. Bandwidths greater than 10Gbps are desired, with a 40Gbps threshold and over 100Gbps objective on a single beam.

REFERENCES:
2. https://www.meshdynamics.com

KEYWORDS: High Bandwidth, Mesh, Wireless, Secure, Network, Localized,
TITLE: Non-Destructive Evaluation of Bonded Interface of Cold Spray Additive Repair

RT&L FOCUS AREA(S): General Warfighting
TECHNOLOGY AREA(S): Air Platform

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OBJECTIVE: The purpose of this effort is to provide a non-destructive evaluation (NDE) inspection process to verify the cold spray bond line, ensuring good adhesion to the aviation component.

DESCRIPTION: It is the intent for the offeror to demonstrate acceptable cold spray material properties with non-destructive evaluation (NDE) method development identifying degraded cold spray bulk material properties and/or adhesion to a substrate. Qualified performers must demonstrate that they have a cold spray capability (in-house or partnership with a company). Samples must be provided containing intentional defects created by this carefully controlled cold spray bonding capability, and the NDE techniques to be developed must detect at least 90% of the defects.

The existing NDE method of fluorescent penetrant inspection (FPI) only evaluates the surface. The requirement is for sub-surface NDE of the cold spray bonded interface for use in structural flight critical safety item (CSI) restoration. Since bulk material properties of the cold sprayed coating may influence bond condition, NDE methods must also determine acceptable bulk material properties of the cold spray coating. NDE methods shall be explored and a solution provided to characterize these conditions. There is a need for developing a nondestructive examination method that will determine if the interface bond is intact without destroying the part. This is critical for flight safety on Army aviation components. Defects within the deposit can be the weak areas allowing for fatigue crack initiation and growth. These defects need to be ascertained so the cold spray deposit onto the substrate has acceptable strength, elongation, fatigue resistant, and other characteristics to ensure it will give the same life expectancy as the original component. It is desired that the NDE capability will be developed from this SBIR to ensure that the cold spray interface bond line is not compromised when it is applied and when it is returned to the depot for overhaul to ensure continued flight safe operation after overhaul.

Pre- and post-process with possible in-situ NDE development of the cold spray process shall be accomplished on cold sprayed coupons prior and after testing specifically ensuring no cracks, excessive porosity or contaminants, and good adhesion (25,000 psi). Use of cold spray process parameter adjustment or introduction of contaminants to establish a non-acceptable cold spray deposit is expected during research and development of the NDE method. Various NDE methods may include eddy current, ultrasonic, computed tomography (CT) radiology, or other techniques. The cold spray powder and process used should be sufficient to establish structural integrity on aluminum and magnesium substrates (Aluminum (Al) 7049 forged, Magnesium (MG) forged AZ80A, and Mg ZE41A) during the NDE development.

Typical acceptable cold spray deposit are adherent to the substrate material, showing a uniform continuous surface free from blisters, voids, spalling, chipping, flaking, cracking, lumps (berries), loosely
adherent spattered particles, and other objectionable imperfections. Microscopic examination of the cold spray does not exhibit any cracks, excessive or massive oxides or porosity when examined at a minimum magnification of 100X per ASTM E3, E407, and E1920. Oxide and porosity content are usually less than 2 percent when viewed at 100X minimum per ASTM E2109. Acceptable bond strength is near the 25000 pounds per square inch per plug bond testing. No de-bonds or delamination are to be present in the cold spray bond line. Hardness minimum is 70 Vickers minimum on as deposited 6061 cold spray powder. The CCDC AvMC Aviation Engineering Directorate (AED) has tapped Army Research Laboratory's (ARL) cold spray research, however ARL recommended NDE process assessment of properties using frictional sliding (presented at cold spray action team (CSAT)) does not establish sub-surface evaluation at the degree of resolution needed in aviation CSI components. The success criteria is ability to detect degraded interface bond to an acceptable probability of detection (POD).

PHASE I: Develop NDE method(s) to determine an acceptable cold spray interface bond during the cold spray process, inclusive of cold spray coating bulk material properties. The innovation desired of phase I is to give the Army aviation the capability to detect subsurface (internal) cold spray flaws from the smallest critical size, interface delamination, bulk properties in thin, medium thick, and thick deposits. The offeror shall be able to inspect subsurface (internal) flaws for any linear size indications. (Note- current critical size visibly detectable on surface inspection via NDE method(s).)

Comparison example of external surface inspection criteria (using NDE method fluorescent penetrant inspection (FPI)) on critical safety items (CSI) requires detection of cracks and corrosion (any linearity size visually detectable) and thru-wall indications (any linearity size visually detectable), of which no indications are allowed. Using NDE surface method FPI, non-CSI parts (lower quality) may allow indications of up to 0.010 inch in diameter of porosity/cold shuts/shrinkage/inclusions.

The effort shall require cold spray of coupons with NDE development pre- and post-evaluation and in-situ of subsurface (internal). The cold spray ranges from the thin coatings (deposits) (0.010 -0.050 inch thick coatings), medium thick coatings (deposits) (0.1 – 0.5 inch thick coatings), and thick coatings (deposits) (0.5 – 1 inch thick coatings). This NDE developed method(s) should include the capability to detect the cold spray interface bond line for any linearity size delamination, cracks, porosity, contaminants, and weak cold spray bonded interface resulting from cold spray parameters (e.g. critical velocity, pressures, gas flow, etc.) while providing quantitative material condition results. The offeror will be required to develop detection methods for subsurface (internal) flaws in the thin and medium coatings, linear or diameter. If successful on the thin and medium thick coatings, then the thick coatings will be attempted as well.

Metrics for phase I include for thin (0.010-0.050 inch) and medium thick (0.1-0.5 inch) coatings (evaluation based on NDE with performance testing via coupon testing (ASTM E8, E466, R.R. Moore (bend/rotate)):

- Demonstrate NDE method(s) capability to detect flaws (cracks, delamination, porosity, contaminants, weak bond interface).
- Demonstrate NDE method(s) smallest critical size of flaws detectable (cracks, delamination, porosity, contaminants, weak bond interface). (Critical indication flaw size should equate (similar) to a visual discernment on external surface for indications less than 0.010 inch linear or diameter using FPI method)
- Demonstrate NDE method(s) capability to inspect bulk properties of the cold spray (densities, acoustics, etc. that are not influenced by interfaces (boundaries).
- Upon successful demonstration of thin and medium thick coatings, then thick coatings (0.5-1 inch) shall be demonstrated in subparagraphs a. through c.

ARMY 36
For NDE detection development it is expected that an unacceptable cold spray process will require seeding of faults (parameter adjustment, contaminant introduction, etc.). The material characterization of the cold spray shall be accomplished during the research effort and be inclusive of failure mechanisms, residual stress, microstructure, microhardness, mechanical properties, etc. The deliverable of the project includes recommendation of inspection equipment and NDE method(s) along with substantiated results. All research and development processes shall be documented and reported for potential replication. NDE methods with greatest promise shall be highlighted and recommended for Phase II demonstration.

PHASE II: Deliverable will be the design, development, and fabrication of a prototype NDE method(s) from phase I to include motion control, data acquisition system, data reduction (software), used to detect sub-surface cold spray interface bond and bulk material properties characterization during research and development of statistically sound repeatable results for aerospace application of the cold spray process. The success criteria will be an established probability of detection (POD) 90% with 95% confidence. The offeror shall develop a NDE method to along with the examination of the cold spray interface bond. This phase II will assess, describe, and develop a NDE method that will establish the ability to detect a particular defect, (delamination, crack, porosity, contaminants, weak cold spray bonded interface) along with identifying the size, orientation, and location of the defect. Typical four options that constitute the probability matrix of include:

- An item is flawed and the NDE method detects it (True Positive).
- No flaw exists and the NDE method indicates a flaw present (False Positive).
- An item is flawed and the NDE method does not detect it (False Negative).
- No flaw exists and the NDE method has no indication of a flaw (True Negative).

Probability of detection (POD) studies such as this SBIR is requiring for development is to be done, possibly by plotting the accumulation of flaws detected by a newly developed NDE method against the flaw size of all flaws “detected” (or that produce a response over some threshold). Ideally all flaws over some critical size will be detected and flaws smaller than that are not “detected”. A common tool used for POD is the POD curve, probability of detection versus flaw height.

A demo system will be developed incorporating the NDE method including all data processing methods developed in Phase I and Phase II.

PHASE III DUAL USE APPLICATIONS: Upon successful completion of Phases I and II, the actual NDE method will be implemented in a cold spray additive repair process for actual Army aviation components. The demo system built in Phase II will be modified and adapted for inspection of selected prototype part geometries. Finally, the cold spray repaired prototype components will undergo full scale fatigue testing as required by Aviation Engineering Directorate (AED) using the NDE demo system for inspection and quantifying degraded cold spray properties and adhesion. Upon successful completion of any further testing required (i.e. corrosion, etc.), a maintenance engineering order will be established allowing repair and overhaul production.

REFERENCES:
3. ASTM E3, Standard Guide for Preparation of Metallographic Specimens
4. ASTM E8, Standard Test Methods for Tension Testing of Metallic Materials
6. ASTM E18, Standard Test Methods for Rockwell Hardness of Metallic Materials
7. ASTM E407, Standard Practice for Microetching Metals and Alloys
9. ASTM E466, Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials
10. ASTM C633, Standard Test Method for Adhesion or Cohesion Strength of Thermal Spray Coatings

KEYWORDS: Cold Spray, Nondestructive Evaluation (NDE), eddy current, ultrasonic, computed tomography
TITLE: Compact, High Performance Engines for Air Launched Effects UAS

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Air Platform

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OBJECTIVE: Develop and demonstrate low volume, high performance engine systems to power Air Launched Effects (ALE) unmanned aerial systems (UAS) for increased operational capability.

DESCRIPTION: Tactical requirements for ALE unmanned aerial systems are exceeding current capabilities for performance (payload, range/endurance), low noise capability, reliability, maintainability, and supportability. Mission requirements such as extended range/endurance, increased power, low altitude operation without detection, and high reliability are becoming paramount. These requirements are not currently fully realized with conventional rotary, internal combustion, or turbine-based propulsion. Electrical power requirements for advanced payloads is also increasing, which adds weight to the air vehicle. Current UAS conventional engines tend to be noisy, which can limit UAS operational capabilities. Various advanced engine concepts offer the potential for significantly increased power to weight/volume ratio. The objective of this topic is to develop advanced, small engines (approximately 10-30 horsepower) which can fit in a defined installation envelope while having low noise characteristics and low specific fuel consumption (threshold 1.2 lb/hp-hr, objective 0.6 lb/hp-hr). The threshold size for the installation envelope is no larger than 13 inch height by 10 inch width by 21 inch length, while the objective size is 10 inch height by 10 inch width by 21 inch length. The output shaft should be aligned parallel to the length axis. Specific power goals for proposed engines (including the weight of all ancillaries required for operation such as control systems, cooling systems, gearbox (if required to meet output speed below), etc.) are .5 hp/lb threshold and 1.5 hp/lb objective. Reliability goals for proposed engines includes mean time between overhaul (1000 hours threshold, 2000 hour objective) and mean time between essential function failure (1000 hours threshold, 2000 hour objective). Additional key capabilities include the ability of the engine to operate off of heavy-fuel (JP-8, diesel, and alternative fuels) and ability to provide power to electrical payloads (1 kW). Output shaft design speed should be 4000-7000 rpm.

PHASE I: During Phase I effort, all major components of proposed engine concepts should be, as a minimum, designed and validated via either modeling or subscale testing to substantiate the ability to provide adequate power for propulsion, fuel consumption for endurance, as well as meeting reliability, specific power, and volume goals.

PHASE II: Phase II will fully develop, fabricate, and demonstrate a demonstrator engine system in a ground test environment.

PHASE III DUAL USE APPLICATIONS: Phase III options should include endurance testing and integration of the enhanced propulsion system into an ALE UAS airframe and demonstrate the performance of the system with flight testing in an ALE mission environment.
REFERENCES:

KEYWORDS: unmanned aerial system, propulsion system, heavy fuel engine, power to weight ratio, fuel efficiency, low noise
A20-113

TITLE: Optical Based Health Usage and Monitoring System (HUMS)

RT&L FOCUS AREA(S): network
TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop a Health and Usage Management System utilizing fiber optic inputs and sensors for operational data recording and analysis that will improve flight safety, mission readiness, and effectiveness.

DESCRIPTION: The Army is seeking novel approaches to developing a Health and Usage Management Systems (HUMS) that has the ability to collect data from a number of fiber optic sources that measure strain, pressure, temperature, and acceleration from critical components on the vehicle. Typical HUMS systems receive inputs from the airframe, engines, and avionics and analyzes the data in real time to provide updates on the state of the vehicle. Data trends such as an increase in vibration on a specific component can be used to identify the beginning of a catastrophic failure and provide the pilot with the information, preventing loss of the vehicle. Fiber optic based sensing and data collection has the advantage of being significantly lighter than more traditional measurement methods, immune to EMI from other sources, passive such that an RF signal is not emitted from the vehicle, and enables highly multiplexed sensing such that >40 measurements can be made on a single channel. With the increasing use of composite structures, the ability to detect and interpret fatigue failure and cracking in addition to vibration measurements is highly desired. Due to the flexibility of optical fiber systems, it is strongly encouraged that the developed system supports additional measurements and measurement locations on the vehicle. It is also strongly encouraged that offerers demonstrate a relationship with a successful military systems integrator as part of the transition plan.

The fiber optic HUMS will need to be tested in accordance with MIL-STD-810G specifications for environmental robustness. It will need to receive inputs from up to several sensing locations:

- Total volume of sensors: > 500 sensors, across >12 parallel optical fibers
- Simultaneous and concurrent detection across all sensors
- Absolute wavelength accuracy with traceable on-board referencing
- Continuous dynamic range (loss budget) of >20 dB per channel
- Flexible acquisition rates 2 – 5kHz
- Survivability and operation at vibrations up to 5 G rms, 15Hz to 2000Hz, per 514.7C-VI from MIL-STD-810G
- Long term operating temperatures of -30 to 85C, Storage temperatures of -50 to 125C, short term in-spec operating temperatures of -50 to 120C,

PHASE I: Design a flight qualifiable the architecture for a HUMS system meeting the above specifications that receives inputs from fiber optic strain, temperature, and vibration sensors. Phase I should also demonstrate the flight readiness of key optical components and electrical designs in accordance with MIL-STD 810G specifications.

Paper study and some hardware.

PHASE II: Develop the architecture designed during Phase I into a testable HUMS system. Upon completion of the Phase II a prototype HUMS should be delivered to the Army for further testing.

PHASE III DUAL USE APPLICATIONS: The HUMS system developed during this effort has applications on similar civilian airframes that face many of the same challenges as their military counterparts. Once the system is developed it will be transitioned to the Project Management Offices for
The technology developed here would have significant bearing on the commercial airline industry as well.

REFERENCES:

KEYWORDS: Health and Usage Monitoring (HUMS), Sensors,
TITLE: 3-D Microfabrication for In-Plane Optical MEMS Inertial Sensors

RT&L FOCUS AREA(S): Microelectronics  
TECHNOLOGY AREA(S): Electronics

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OBJECTIVE: MEMS inertial sensors using electromechanical readout approaches have achieved tactical grade performance in small inexpensive form factors. The objective of this effort is to demonstrate three-dimensional microfabrication approaches to achieve micro-optical inertial sensors capable of going beyond tactical grade while maintaining the form factors typical of current MEMS sensors.

DESCRIPTION: Army missile systems are continuing to become smaller and less expensive. In addition, these systems face ever increasing threats to GPS availability. These factors are driving advancement in small and inexpensive, yet high-performance, inertial sensor technology. MEMS technology has demonstrated small form factors for relatively inexpensive inertial components that are suitable for tactical grade operation. However, as missile systems decrease in size and must operate for extended periods of time in GPS-denied environments, future small inertial sensors must demonstrate increasingly higher levels of performance.

MEMS inertial sensors utilizing electrostatic, piezoelectric, and magnetic proof mass displacement readout approaches have achieved success in both commercial- and defense-related applications. However, there is a desire for improved performance suitable for navigation-grade applications. This program proposes the development of technology that could yield the next generation Micro-Electro Mechanical Systems (MEMS) navigation-grade inertial sensor. The majority of MEMS inertial sensors utilize electromechanical readout of the motion of a micromachined proof mass. It is anticipated that these “traditional” MEMS pickoff techniques (capacitive, magnetic, piezoelectric, etc.) will not be able to achieve the required performance levels. Optical readout of mechanical displacements has demonstrated high levels of resolution in macro-scale applications including precision movement and placement systems. In addition, optical techniques are common in high performance inertial sensors such as fiber optic gyros and ring laser gyros. Incorporating optical readout approaches into MEMS acceleration devices may yield sufficient resolution to achieve navigation-grade performance.

However, the integration of micro-optical components within MEMS devices suffers from multiple issues. Hybrid integration of micro-optical components is commonplace for electro-optic devices such as tunable lasers, modulators, detector arrays, and other complex optical systems. However, for MEMS components with released microstructures, the required microassembly processes suffer from the need to perform component alignment, place and contain adhesives, and attach components to movable structures. In addition, hybrid microassembly is not amenable to wafer-scale processing, leading to difficulties in controlling final component cost. Monolithic integration of micro-optical components within MEMS inertial sensors addresses these issues by providing benefits such as self-alignment and wafer-level fabrication. However, the fabrication of micro-optical components, such as lenses, mirrors, and beam splitters, directly within MEMS components has been limited primarily to the creation of out-of-plane features. These features can be used to realize out-of-place optical MEMS inertial sensors.
through approaches such as wafer stacking. However, there are few options for fabricating in-plane micro-optical features that can realize in-plane MEMS inertial sensors.

The goal of this program is to develop approaches to realize in-plane MEMS inertial sensors that utilize monolithically fabricated micro-optical components for precise proof mass position sensing, thereby enabling high levels of inertial sensor performance without increasing potential form factors and costs. 3-D microfabrication approaches can include such items as sidewall micromachining to achieve vertical high-quality micro optical surfaces, multi-level waveguide fabrication approaches to guide light between sources, detectors, and various micro-optical surfaces on the MEMS structure, self-assembled structures to create micro-optical functionality after chip fabrication, amongst other techniques. The performance goals for this effort are 1) range $\geq \pm60$ g, 2) Bias Instability $\leq$20 $\mu$g, 3) Scale factor stability $\leq$50 ppm, 4) Volume < 5 in$^3$.

PHASE I: Conduct a design study with detailed fabrication and model development for each component of an in-plane optical MEMS inertial sensor. Predict in-plane optical surface quality for the selected 3-D microfabrication processes. Estimate optical MEMS inertial sensor performance based on potential optical quality. Perform proof-of-principle experiments to investigate 3D microfabrication process performance.

PHASE II: Develop and deliver a functional prototype MEMS inertial sensor with a 3D microfabricated optical pickoff. Characterize the resolution of proof mass displacement measurement. Characterize inertial sensor performance specifications.

PHASE III DUAL USE APPLICATIONS: Deliver a fully functional MEMS inertial sensor with a 3D microfabricated optical pickoff. Additionally, documentation verifying inertial sensor performance characteristics shall be included with each device delivered. Reported inertial performance characteristics should include scale factor, scale factor error, and bias instability. Measures of angle random walk and velocity random walk shall be included in the inertial sensor performance characteristics for gyroscopes and accelerometers respectively. The inertial sensor technology developed in this effort can be applied to commercial aviation, aerospace, and maritime guidance systems. The optical pickoff technology developed in this effort can also be applied to non-inertial microsystems such as telecommunication integrated optics modules, active alignment systems in microassembly approaches, and nanopositioning devices.

REFERENCES:
KEYWORDS: MEMS, Optical Inertial Sensor, Displacement Measuring Interferometry
TITLE: Using Artificial Intelligence to Optimize Missile Sustainment Trade-offs

RT&L FOCUS AREA(S): AI/ML  
TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop methods to use artificial intelligence (AI), machine learning, and real-time computational intelligence to optimize Army logistics and sustainment simulations and predictions for both legacy and future Army missile systems.

DESCRIPTION: The CCDC AvMC Logistics Engineering Lab (LogLab) developed a sustainment simulation capability for Army aviation using a government-owned software tool called System of Systems Analysis Tool (SoSAT). Multiple PM's use this capability to conduct analysis and provide input for major acquisition documents. The LogLab is looking to upgrade the simulation capabilities of the software tool using artificial intelligence and machine learning to optimize logistics outcomes for CCDC AvMC customers like Hypersonics. Artificial intelligence would determine strategies of sparing, costs, supply chain locations, maintenance staffing, maintenance levels, scheduled maintenance times, to best measure and optimize sustainment options and logistics support for Army missile systems. Identify missile platform life cycle metrics, such as Materiel Availability (Am), Operational Availability (Ao), sparing, cost, maintenance man-hours, and other KSA's, to be optimized by AI. Provide to a logistics engineer knobs to turn to see effects on metrics such as system reliability, system availability, system downtime, administrative delay time, maintenance man-hours, manpower, and OPTEMPO. Additionally, consider a Material Availability (Am) model to also include full life-cycle and fleet-wide sustainment concerns such as fielding schedules, recaps, resets, demils, software and hardware upgrades, modernizations, etc.

SoSAT is a government-owned software package and will be provided. Notional and/or representative Army missile reliability and supply data will be used. The size of the dataset will also be representative of actual datasets used and expected to be used by future Hypersonics systems -- a typical 30-year Army sustainment model is approximately 25GB, and multiple models could be combined, yielding datasets in the range of 100-200GB. Any AI solution will need to run on US-government network computers and will be export controlled.

PHASE I: Perform a design study to determine how to use artificial intelligence, machine learning, and real-time computational intelligence to optimize sustainment and logistics support. Deliver a final design of AI's capabilities, a simulation model of Army missile assets (including systems of systems), and a demonstration of an AI-infused logistics model capable of making intelligent trade-off decisions to meet specified PM threshold and objective sustainment metrics -- specifically, downtime and readiness levels as calculated by Army missile systems, using inputs such as failure rates, ALDT, repair times, and maintenance man hours. A successful design will be able to optimize support, minimizing missile system downtime and maximizing system availability, using logistics inputs (component failure rates, repair part shipping times, repair times, maintenance man hours and maintainer staffing). Designed AI must be capable of handling, learning from, living in, and analyzing datasets upwards of 200GB in size. Designed
AI must also show a 75% reduction in results data processing time over current methods, a 10% reduction in data input, import, and formatting time over current methods, and a 30% reduction in output dataset size. Test method to determine success for above metrics will be accomplished through analysis.

PHASE II: Deliver and implement a working prototype of an AI-infused logistics model (as designed in Phase I) capable of deep learning and making intelligent trade-off decisions to meet specified PM threshold and objective sustainment metrics. The model will also provide the capability to measure the impacts of technology insertions, obsolescence, reset, and other significant events in the entire Army missile platform's life cycle, and to optimize such downtime and upgrade scheduling over that typical life cycle. Prototype AI must be capable of handling datasets upwards of 200GB in size. Prototype AI must be able to learn from baseline sustainment datasets, learn from excursion datasets on the fly, and apply learned behaviors. Prototype AI must show a 100% reduction in results data processing time over current methods, a 20% decrease in data input, import, and formatting time over current methods, and a 50% reduction in output dataset size. Test method to determine success for above metrics will be accomplished through demonstration. Mission profiles and operations in the model will be based on notional Army missile concept of operations (CONOPS).

PHASE III DUAL USE APPLICATIONS: Deliver a polished and complete working AI-infused logistics sustainment model making intelligent trade-off decisions to meet specified PM threshold and objective sustainment metrics to all Army PM's and for current and future Army missile platforms. The final product should model and optimize logistics and sustainment at multiple levels of fidelity from battalions to component parts, from components to systems of systems, from individual missions to entire life cycles, use advanced web and cloud services to compute and be hardware-independent, may include an asynchronous mobile application to view and sort results, handle upwards of 1TB of data, and be hosted or otherwise available to all CAC-enabled personnel. Test method to determine success for above metrics will be accomplished through operations.

REFERENCES:

KEYWORDS: artificial intelligence, logistics, simulation, modeling and simulation, sustainment, availability, reliability, maintainability, supportability, software development, machine learning, neural networks, real-time computational intelligence, data science,
TITLE: Distributed Beamforming for Non-Developmental Waveforms

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: To facilitate the adoption of resilient communications within the Army by developing the capability to apply distributed beamforming techniques to non-developmental waveforms for cost effective communication systems with greater range and power-efficiency and lower detectability than current communications technologies.

DESCRIPTION: The US Army C5ISR Center is interested in the development of technology to enable the application of distributed beamforming communications techniques to non-developmental waveforms. Distributed beamforming techniques have matured significantly over the past decade, but currently rely on unique waveforms often with costly computational and hardware requirements. The ability to apply distributed beamforming techniques to non-developmental waveforms can greatly facilitate integration of the technology into tactical communications architectures.

Distributed beamforming using dismounted soldier radios can emulate an antenna array and obtain power and/or directivity gains which are proportional to the number of dismounted radios, and be used to deliver a common message to a mounted receiver or possibly another collection of dismounted soldiers. Benefits of distributed beamforming include energy efficiency, improved communication range (or an equivalent lowering in detection range with respect to an adversary), interference rejection, and possibly the ability to spatially multiplex streams of data if desired.

The C5ISR Center particularly seeks techniques, which can be used for squad level communications. The Army squad must be able to communicate with a separated parent vehicle in poor visibility or over restrictive terrain in a manner which reduces vulnerability to enemy interception/detection (LPI/LPD) and enhances Anti-Jam (AJ) capabilities in congested/contested environments.

The US Army SBIR office and C5ISR Center are requesting information related to distributed beamforming methods designed for dismounted soldiers where each soldier has a radio and omnidirectional antenna, and where each soldier acts as a node in the distributed dismounted beamforming system. The dismounted soldiers must be able to communicate, in a cooperative manner, with a radio mounted on a vehicle, where the mounted radio may use multiple antennas. The capability must demonstrate AJ/LPI/LPD characteristics while operating in a congested/contested environment. Waveforms in consideration for this effort should be non-developmental in nature. The ability to update existing tactical radios with this capability via software/firmware update is highly desirable. The approach should maximize portability and backwards compatibility to tactical radio systems which will support widespread implementation and reduce overall cost. Consideration will be given to government owned and government purpose waveforms. The Joint Tactical Networking Center (JTNC) DoD Information Repository and JTNC Tactical Communications Marketplace, both available at https://www.public.navy.mil/jtnc/Pages/home.aspx, are resources to gain access to these waveforms.
The proposal should contain information regarding the beamforming (or diversity) implementation, and specifically how LPI and LPD are improved by the beamforming methods. Furthermore, the proposal should contain any information regarding the characteristics of the beamforming methods that facilitate improved resistance to intentional and non-intentional interference, both from enemy and friendly forces in congested/contested environments.

Typical concepts of operation would include forward dismounted reach-back to a vehicular platform that may or may not be under condition of enemy electronic warfare (EW) attack (electronic support (ES) and electronic attack (EA)), support for route clearing operations that might use a Counter Remote Controlled Improvised Explosive EW (CREW) device to block enemy communications, and tactical dismounted operations in dense urban terrain typical of building search and clearing, which are assumed to be highly congested/contested environments.

The system must provide up-echelon communications to at least 5000m to a reach back node that is mounted or dismounted. The solution must also provide communications, AJ, LPI, and LPD capabilities when the reach-back distance is lower than 5000m. Frequency Bands of interest are VHF, UHF, L-Band, and S-Band. Real time voice, push-to-talk (PTT), and data demonstration is expected as a part of this effort. Open standard and non-proprietary interfaces shall be available for connection of audio and data connection ports.

Data rates will be available to support transfer of voice and position location information. Solutions which provide additional data rates which support file transfer and streaming video services are also of interest.

PHASE I: The Phase I effort shall include a feasibility study of the incorporation of distributed beamforming methods to non-development waveforms to include frequency offset and time/phase synchronization as well as the impacts of other waveform aspects such as modulation and coding. Additionally an overall consideration of system architecture feasibility incorporating the various individual blocks (modulation, synchronization, demodulation, etc.) should be included.

An analysis of the theoretical limits of the various technical approaches shall be presented in addition to any practical limitations for the approaches. Analysis should be reinforced with simulation of the approaches. The Phase I effort will identify the optimal approach and provide a recommendation for Phase II implementation. The Phase I deliverable will be a report documenting the results of the feasibility study and simulation software with short exemplary use-cases for the simulation software allowing reproduction of some key simulation results from the report.

PHASE II: The Phase II effort shall implement and demonstrate the operation of a TRL 5/6 prototype distributed beamforming system using a non-developmental waveform(s). The prototype systems shall incorporate the techniques researched in Phase I. The prototype shall be delivered to the government with an associated user manual and a report documenting the results of the Phase II effort.

The system is expected to be evaluated and demonstrated at the Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) Center Ground Activity in Ft. Dix, NJ. The demonstration shall include full beamforming with a minimum of 4-nodes. The system architecture should be scalable and support team sizes of at least 11-nodes. It is further desirable to support squad-to-squad beamforming without a dedicated base station. The Army is interested in performance in unobstructed line of sight (LOS), restricted, and urban terrains under benign and contested electromagnetic environments.
The Phase II effort shall include an operationally relevant field demonstration of the prototype systems, which demonstrates at least real-time transfer of voice/PTT and position location information (PLI) data. Demonstration of higher throughput applications is desirable. The test environment shall be a GFE provided test facility.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will focus on reducing the size, weight, and power of the Phase II prototype, maturing the prototypes to TRL 6/7 for integrating into the appropriate Army Program of Record. The technology developed under Phase II may also be modified and transitioned to the commercial cellular industry for appropriate use in 5G (or other) systems. The capability proposed in this SBIR is beneficial to commercial uses for first responders in disaster relief communications where critical communications infrastructures are unavailable. Distributed beamforming of small teams increases the reach-back communications distances; especially in challenging environments with path obstructions such as buildings or foliage.

REFERENCES:

KEYWORDS: Communications, distributed beamforming, cooperative beamforming, collaborative beamforming, synchronization, radiation pattern, near-field, far-field, space-time, electronic warfare, interference mitigation
TITLE: Lens Antennas for Resilient Satellite Communications (SATCOM) on Ground Tactical Vehicles

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop and demonstrate a vehicular mounted, On the Move (OTM) lens antenna capable of satellite communications with Low Earth Orbit (LEO), Medium Earth Orbit (MEO) and Geosynchronous Earth Orbit (GEO) constellations simultaneously.

DESCRIPTION: The Army must leverage emerging LEO and MEO satellite service for tactical communication to remain competitive with foreign adversaries. The Army intends to integrate this capability into the existing Army GEO SATCOM terminals, to provide resilient transport links for multiple networks simultaneously.

As the technology development organization for the U.S. Army Futures Command (AFC), the Command, Control, Communication, Computers, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR) Center, provides research, development and engineering support for Army satellite communications. In this role, STCD is seeking to partner with a small business to develop a new satellite antenna capability of supporting communications diversity on the battlefield. The focus is on providing an affordable technology that has the potential to meet performance requirements to close multiple simultaneous connections to geosynchronous and other Wideband SATCOM systems, typically at X, Ku, and Ka bands. The antenna technology is required to meet Size, Weight and Power (SWaP) requirements for integration on a ground tactical vehicle. The antenna technology will be required to support tracking for LEO, MEO and GEO satellites.

The antenna must present an innovative path forward for cost reduction that will contribute to an affordable resilient next generation tactical terminal with multi-beam capability. The multi-beam antenna technology should be capable of supporting multi-megabit per second connections to multiple satellites simultaneously in different types of orbit, and be easily deployed. The technology is meant to be deployed on a ground tactical vehicle and should use commercial processes to drive affordability. This capability when complete will support added resiliency for the U.S. Army and Multi-Domain Operations (MDO) mission threads in a contested environment which aligns directly with Army Modernization Priorities, Long Range Precision Fires, Next Generation Combat Vehicle and Army Network.

Historically, parabolic dish antennas have been the chosen architecture for Tactical SATCOM systems. These systems make up the majority of the Army’s tactical vehicle inventory. Parabolic dish antennas offer a low cost solution, with antenna performance that meets military requirements for Effective Isotropic Radiated Power (EIRP), Receive Gain / Temperature (G/T), and SWaP. However, these systems are limited in providing multi-beam and multi-band solutions necessary for an integrated LEO, MEO, GEO SATCOM capability.

A second type of antenna, heavily used for Military SATCOM are phased arrays. These antennas offer multi-beam and multi-band solutions, but are often challenged with the total cost and field-of-regard (i.e. performance at low elevation angles) which is critical for performance on tactical vehicles. A new generation of Army tactical terminals is necessary to meet existing military performance requirements and provide a multi-beam, multi-band SATCOM capable solution, with the broad field-of-regard critical for Army tactical vehicles, at a cost the Army can afford.

Lens antennas offer a host of new architectures, from which to build a multi-band, multi-beam terminal. Lenses, similar to dishes, passively focus Electro Magnetic (EM) waves which greatly reduces antenna
cost. Further, lens technology offers 3-dimensional way to collect electromagnetic waves, and therefore provide the field-of-regard critical for Army tactical vehicles.

PHASE I: Develop an initial design of a SATCOM lens antenna and terminal, meeting the Government performance requirements for Tactical SATCOM OTM (available from Government TPOC, upon request). The initial design should evaluate the full SATCOM terminal system, and utilize modeling and simulation to support the design.

PHASE II: Develop functional prototype SATCOM lens antenna and terminal. Demonstrate SATCOM connectivity over LEO, MEO, and GEO satellites, in a laboratory setting.

PHASE III DUAL USE APPLICATIONS: Package the potential solution for a field based test. Demonstrate SATCOM connectivity over LEO, MEO, and GEO satellites, in a field environment. Engage commercial partners to use the product in this field test alongside military operation.

REFERENCES:

KEYWORDS: Communications, Printable nanocomposite inks, lens, Wideband SATCOM, Additive manufacturing, antennas
TITLE: Novel, Low SWaP-C Unattended Ground Sensors for Relevant SA in A2AD Environments

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop and demonstrate novel, very small, inexpensive radio frequency (RF) sensors that can be distributed in mass quantity over an operational zone to gather relevant Situational Awareness (SA) data on millimeter wave signals.

DESCRIPTION: The US Army Combat Capabilities Development Command (CCDC) C5ISR Center is interested in experimenting with low-cost, very small Size, Weight, and Power (SWaP) unattended ground sensors (UGS) to maintain situational awareness (SA) within a signal dense (e.g. urban centers) and contested (e.g. limited air superiority) area of operations that require a ubiquity of sensors not achievable by conventional means.

The UGS would be readily distributed within an area of interest to provide the ability to sense the Cyber-Electromagnetic Environment (C-EME), allowing for the acquisition of data required to achieve CyberSpace Situational Understanding (CYBER SU) and improve network survivability. The collected sensor data would support multiple objectives, to include environment mapping, specific signal of interest detection and geo-referencing, and battle damage assessment. In addition, the UGS could be deployed hundreds of miles forward of a Forward Line of Troops (FLOT) from platforms such as high altitude (i.e. >60K feet) balloons to support acquisition of target data for long-range precision fires.

The sensors could leverage emerging Internet of Things (IoT) protocols (or comparable performing waveforms) for data retrieval. Sensors will at a minimum contain the following core functionality: GPS, CPU, non-volatile memory storage, data retrieval waveform and Tx/Rx chain, power management system (to include battery), accelerometer (optional, but highly desirable), and compass (optional, but desirable). Given the small size, weight, power, and cost objectives, it is envisioned that such sensors would only perform a single specific sensing objective. However, the design would ideally allow for the rapid integration of various different types specific EM signals or other modalities (i.e. seismic) of interest within the core sensor package.

C5ISR Center is seeking to partner with a small business to develop UGS that can affordably be distributed in mass quantities. The partner should analyze and describe trades involved in the various size, weight, power, cost, and longevity envelopes.

Other Design Considerations:

• Given the small size, weight, power, and cost objectives, it is not envisioned that sensors will be able to communicate and collaborate with each other. However, this is not prohibited.
• A persistent connection between the data aggregation system and the sensor field cannot be assumed. The data aggregation system may only be present within range of the sensor field for a transient amount of time.

PHASE I: Develop an understanding of the key technical challenges that exist to support this concept. Identify components and build models (to include power budgets) of the very low cost, highly distributable unattended sensors described above. Conduct trade off studies on the use of existing IoT protocols, or comparable data retrieval waveforms. Work with the government to determine initial desired EM signal for the sensor to detect. Deliver a technical report of Phase I results.
PHASE II: Develop baseline UGS prototypes and demonstrate the sensor with a relevant representative environment. Demonstrate the use of identified data retrieval waveforms to collect data from the UGS as selected from Phase I studies. Deliver multiple prototypes, in sufficient quantity, for C5ISR Center to fully vet the operational concept and performance of such a capability.

PHASE III DUAL USE APPLICATIONS: Advance the UGS sensor to TRL 7/8 and MRL 8. Modify the baseline UGS prototype design and develop variants that collect on additional EM signals and provide other functions such as seismic and chemical, biological, radiological and nuclear (CBRN) monitoring.

REFERENCES:

KEYWORDS: Network/C3I, Long-Range Precision Fires, Battlefield Internet of Things (IoT), Unattended Ground Sensors
TITLE: Efficient Near Field Charge Transfer Mediated Infrared Detectors

RT&L FOCUS AREA(S): Microelectronics
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a scalable and low cost novel charge transfer hetero-interface architecture for high quantum efficiency infrared (IR) detector technology operating at near room temperature with response cutoff wavelengths of 5 and/or 10 micron IR radiation.

DESCRIPTION: Infrared imaging systems have been an important capability for the U.S. Army to ensure day and night situational awareness. In future conflicts, it would be necessary to deploy imaging capability to squad and individual Soldiers. While Longwave Infrared (LWIR) uncooled thermal imaging capability is gradually becoming available to Soldiers, these cameras do not offer flexibility in F/#, sensitivity, frame-rates, or range. High performance Midwave Infrared (MWIR) and LWIR quantum detector based imaging systems can solve many of these issues. However, the cooling requirements, Size, Weight and Power (SWaP) and high cost of production prevents high performance systems at the Soldier level and smaller platforms. Traditional approaches to increase operating temperature in MWIR and LWIR detectors that can operate near room temperature have been unsuccessful. A new approach whereby photon to electron transduction that take advantage of efficient charge transfer across a hetero-interface to separate electron-hole pairs is needed.

A recent body of research1-3 in two-dimensional materials has demonstrated promising new optoelectronic devices based on near-field coupling via interface charge transfer. More studies are needed to understand the hetero-interfaces. The underlying concept in these studies is to implement mechanisms similar to Förster or Drexel energy transfer for electron or hole collection leading to very efficient processes. These studies also show promise to increase the operating temperature. For example, energy transfer across van-der-waals hybrids of graphene and transition metal di-chalcogenides may occur via simultaneous two-way electron transfer via exchange interaction or near-field non-radiative energy transfer mechanisms such as dipole-dipole coupling. It should be noted that these studies have been mostly focused on detection of near infrared radiation. There has not been any major work in the longer wavelengths.

This topic aims to understand and develop MWIR (2-5 micron) and/or LWIR (8-12 micron) detector technology that can operate near room temperature by implementing and testing the efficacy of the above-stated ideas. The goal is to demonstrate operating temperatures of greater than 250K (MWIR) and 150K (LWIR) with quantum efficiencies better than 60% in both bands. Solutions are being sought for novel innovative concepts to develop either or both bands.

PHASE I: Develop a theoretical model and optimize the optical and electronic charge transfer processes in the chosen hetero-interface structure. Understand the underpinning processes to increase the charge transfer efficiency, interface traps and loss mechanisms. Demonstrate the concept and feasibility of the
proposed approach by fabricating single detectors and conducting appropriate materials and detector characterization. Demonstrate proof-of-principle to achieve the above-stated goals.

PHASE II: Based on the Phase I results, perform further development and improvement leading to demonstration of a small array (32 x 32 or larger), test device characteristics in a fan out configuration and deliver to the Government. Conduct a full trade study analysis of the array to establish the case for scalability to larger arrays. Integrate the appropriate array with available Commercial-off-the-Shelf (COTS) ROIC, and build prototype for final delivery of one unit to the Government for laboratory testing.

PHASE III DUAL USE APPLICATIONS: Develop a manufacturing and commercialization plan by partnering with an established IR camera manufacturing firm. Address any shortcomings in the camera design to meet military applications and requirements. These may include applications such as helmet-mounted, weapon-mounted, and Tier I and II UAS for Intelligence, Surveillance, and Reconnaissance (ISR).

REFERENCES:

KEYWORDS: MWIR, LWIR, Infrared, Detectors, Focal Plane Arrays, High Operating Temperature
TITLE: Very Small Pixel Uncooled Longwave Read-Out Integrated Circuit for Enhanced Sensor SWAP and Range Performance

RT&L FOCUS AREA(S): Microelectronics
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a read-out integrated circuit (ROIC) for use on an uncooled longwave infrared (LWIR) bolometer focal plane array (FPA) based sensor having a pixel pitch of 6–8.5 microns. This will enable lower size, weight, and power (SWaP), higher resolution uncooled LWIR sensors for Soldier borne and vehicle mounted applications.

DESCRIPTION: The Army makes extensive use of uncooled bolometer sensors throughout its air, ground, and Soldier portfolios. In nearly all cases there is a SWaP concern, and for many applications it is paramount. A way to increase sensor performance for a given SWaP is to decrease the pixel pitch. The current standard pitch is 12 μm. DoD and industry investments are being made to improve pixel design to enable small pixels, but currently no ROICs exist to take advantage of these investments. As the pixel gets smaller, it becomes more of a challenge to fit appropriate ROIC circuitry within the available space. To overcome this hurdle, hybrid or fully digital circuit architectures may need to be used, perhaps in conjunction with novel physical architectures and fabrication techniques. However, the most desirable approaches will include as many as possible of the following features:

- ≥ 120 Hz full-frame frame rate, preferably ≥ 240 Hz; windowing to even higher frame rates
- Very low power, suitable for small autonomous platform or Soldier-borne applications
- Resolution of ≥1280×1024 pixels
- Bolometer-limited noise performance (ROIC does not significantly degrade noise performance of bolometer)
- Low-cost fabrication techniques and processes
- Very high intra-scene temperature dynamic range

PHASE I: The proposer shall design and model a small pixel ROIC for uncooled LWIR bolometer sensor applications that supports as many of the desired features listed above as possible.

PHASE II: The proposer shall fabricate a small pixel ROIC based on phase I results. At a minimum, results from a device verification test (DVT) for fabricated ROIC wafers must be presented. Collaboration with one or more bolometer manufacturer during this phase is highly encouraged to ensure that the ROIC will support realistic bolometers (e.g. physical form factor, pixel resistivity, etc).

PHASE III DUAL USE APPLICATIONS: With an industry partner, determine an appropriate transition or upgrade path to an Army or DoD customer. Deliver prototype camera systems with 1280×1024 or better resolution for investigation of a variety of problems of commercial and military relevance to the Army where high performance is required in a low SWaP-C package. It is expected that the proposer will
partners with one or more bolometer manufacturer during this phase to fabricate appropriate bolometers on
the ROIC and build of camera.

REFERENCES:
2. Mount, “DRS successfully demonstrates the first 10-micron high performance infrared sensors,”
   10-micron-high-performance-infrared-sensors/
3. Lohrmann, Littleton, Reese, Murphy, Vizgaitis, “Uncooled long-wave infrared small pixel focal plane

KEYWORDS: ROIC, readout integrated circuit, uncooled LWIR, bolometer, thermal, infrared
TITLE: Polarimetric Modeling and Visualization

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop models and visualization tools for multi-modal polarimetric imagery to enhance detection, recognition and identification.

DESCRIPTION: Polarization imaging provides improvements in Detection, Recognition, and Identification (DRI) of objects through contrast enhancements and clutter suppression. The polarimetric data sets are multi-modal and include polarization magnitude, orientation, and conventional intensity information. The physics behind polarimetric signatures is complex and is dependent on the material properties of the scene elements, the shape and the surface characteristics of the objects in the scene, the look angle of the sensor, the relative position of any illumination sources, the relative temperatures of the objects in the scene and the background, and background conditions including weather, cloud cover and the presence and temperature of objects in line of sight of the imaged field of view. Although a first principle model that includes all of these considerations would provide a means to analyze situations and mission parameters in which the enhancement from polarization sensing is optimized, an accurate physics-based model is not practicable. Instead, we seek a hybrid empirical/physical model based on physical modeling and enough testing to develop empirical detection models that can be used to set the mission parameters. Visualization tools are needed to assist a human observer in rapidly detecting and identifying threats in a scene. What is needed is the modeling to predict what should be happening and the visualization tools to achieve successful DRI.

The proposer shall collect or acquire infrared polarimetric data (short-wave, mid-wave, or long-wave) under a variety of conditions and use this data for model development. Detection performance must be quantified through established published metrics. The empirical detection model would ultimately be used for some or all elements of the DRI process and may be implemented into a mission planning tool. The proposer shall develop visualization tools by exploiting the multi-modal nature of polarimetric imaging and thus improve DRI.

PHASE I: Develop and design empirical/physical process for optimizing multi-modal polarimetric image collection with a limited set of parameters. A complete set of parameters will be identified and the subset for Phase I development delineated. Analysis to demonstrate the efficacy of the model is sufficient for a Phase I demonstration. A path for algorithm improvement in Phase II will be established.

PHASE II: Execute the plan developed in Phase I and continue algorithm development. The complete set of mission parameters will be included in the model. A user interface will be developed to facilitate easy input of the parameters. Sufficiently large data sets for development and test will be collected. The algorithms will be implemented on a real-time computing platform and demonstrated.
PHASE III DUAL USE APPLICATIONS: Provide a validated approach for predicting polarimetric camera performance for a variety of military applications and programs. For military applications, this technology will contribute to route clearance, countermine operations, drone-based ISR, and missile seekers.

REFERENCES:

KEYWORDS: infrared, polarimetric imaging, image enhancement, machine learning, artificial intelligence
A20-122

TITLE: Infrared Transparent Adhesive

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop and demonstrate an optical adhesive that is transparent in the Mid-Wave Infrared (MWIR) (3-5 µm) and Long-Wave Infrared (LWIR) (8-12 µm) wavebands.

DESCRIPTION: The U.S. Army develops advance optical sensor components and systems to enhance the situational awareness, survivability, and lethality of the Soldier. To complement these advancements in sensor technology, the Army is seeking novel optical adhesives to facilitate the fabrication of the next generation of sensors. Currently, there is no commercially available adhesive suitably transparent (>0.95) in the MWIR and LWIR. This limits the fabrication methods of imaging systems that operate in these bands. An IR transparent adhesive will allow for the fabrication of unique optical elements, new methods of bonding focal plane arrays to read-out circuits, and development of novel structures such as metalenses and structured coatings. An adhesive that meets the metrics of MWIR and LWIR transparency of >0.95 through a film of 0.5 mm, has a reactive index between 2 and 3, maintains a bond through 100 temperatures cycles of -55° to 125° F, and has maximum tensile stress of greater than 20 N/mm², would find many applications in the Army modernization process. Including the fabrication of imaging systems for the Next Generation Combat Vehicle (NGCV), Future of Vertical Lift (FVL), and Soldier Lethality.

PHASE I: The proposer shall complete a conceptual design of and modeling of an optical adhesive that is transparent in the MWIR and LWIR. This shall include a molecular level design and then modeling of IR transmission.

PHASE II: Using the results of Phase I, synthesize and test an adhesive to meet the performance metrics. For a ZnS to ZnS and a ZnS to Al bond the adhesive should have a maximum tensile stress of greater than 20 N/mm², refractive index of 2.2, persist over 100 temperature cycles of -55° to 125° F, and have an average transparency of 0.95 across the MWIR and LWIR for a 0.5 mm film. At the end of phase two the adhesive will delivered to the U.S. Army CCDC C5ISR Center for further testing.

PHASE III DUAL USE APPLICATIONS: Transition applicable materials to a production environment with the support of an industry partner as, needed. The finalized adhesive that meets the appropriate performance metrics can be transitioned to applications such as Soldier Borne Sensor (SBS), Individual Vision Augmentation System (IVAS), and dual band sensor systems in support of the Army modernization priorities such as the Next Generation Combat Vehicle, Future Vertical Lift, and Soldier lethality. Commercially, this technology will be widely applied in devices that use infrared imaging such as thermal mapping, scientific research, and medical imaging.

REFERENCES:

ARMY 61


KEYWORDS: Adhesive, Broadband IR, Imaging, Sensors, Manufacturing
TITLE: CdZnTe Substrate Screening

RT&L FOCUS AREA(S): Microelectronics
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: This topic seeks the development of a non-destructive technique to unambiguously identify those subsurface defects within the CdZnTe substrate which cause large defects in the epitaxial HgCdTe film. This non-destructive technique shall be able to be scaled up to a manufacturing capability for rapid low cost screening of large CdZnTe substrates before HgCdTe epitaxial film growth is initiated.

DESCRIPTION: HgCdTe infrared detector array technology has improved significantly over the last decade. Single element mm sized detectors made from bulk HgCdTe crystals in the 1960s have been transformed today through research into arrays having more than one million elements with each element measuring below 20 micrometers. This has resulted in DoD infrared systems having much greater sensitivity at a much larger field of view. One major drawback to such large arrays, however, is the yield of such arrays is dramatically reduced by large defects in the HgCdTe film which cause many adjacent HgCdTe detectors to be defective with high noise and lower signal. Recent research has identified the cause of some of these large defects as arising from an imperfect CdZnTe substrate surface. Even after addressing this issue, however, large HgCdTe epitaxial film defects are still driving down the yield of large arrays making their costs rise to prohibitive levels for some applications. New non-destructive technologies are sought which will identify defects below the surface of the single crystal CdZnTe substrate which cause large, yield limiting defects in the HgCdTe films. This technique should be able to be rapidly applied to 7cm × 7.5cm and larger substrates in a manufacturing setting.

PHASE I: Demonstrate correlation between defects identified in the subsurface region of the CdZnTe substrate and large defects in the epitaxial HgCdTe film grown on the same substrate. This correlation shall be shown for a minimum of six defects on at least two different substrates. The HgCdTe films shall be at least five micrometers thick. The composition of the HgCdTe films shall be chosen to represent that composition typically grown which requires large format focal plane arrays. The films shall be grown by a state-of-the-art HgCdTe foundry producing state-of-the-art large HgCdTe arrays.

PHASE II: Modify the subsurface CdZnTe defect detection system to allow for non-destructive rapid inspection of substrates at least 7cm × 7.5 cm in size within the two year period of performance. Demonstrate prototype system on several 7cm × 7.5 cm films with large defects in the films. The prototype system shall demonstrate good correlation between the defects found in the CdZnTe subsurface and large defects seen on the HgCdTe film on the same substrate.

PHASE III DUAL USE APPLICATIONS: Transition operation of a single wafer non-destructive system to HgCdTe foundry operators. Provide supporting documentation for its operation and maintenance. Correlation of subsurface CdZnTe defects with large HgCdTe defects shall be greater than 90%. Time to non-destructively screen a 7cm × 7.5 cm CdZnTe substrate shall be less than 1 hour. Yield of large HgCdTe arrays shall be demonstrated to increase at least 25% after using this non-destructive inspection
system in the HgCdTe foundry. Deliver a lot of substrates and large arrays for verification testing to demonstrate quality, consistency and reproducibility of this inspection method.

REFERENCES:

KEYWORDS: Infrared detectors, CdZnTe substrates, HgCdTe epitaxy
TITLE: No burden / low burden biological air sampler

RT&L FOCUS AREA(S): Biotech
TECHNOLOGY AREA(S): Chem Bio Defense

OBJECTIVE: To develop a passive biological air sampler that integrates into current Personal Protective Equipment (PPE) ensembles. It should be easily deployed and tested in all / many current fieldable biological detection platforms.

DESCRIPTION: Novel technology is needed to overcome the shortcomings associated with this lack of portability and burdensome logistical train associated with biological air samplers. Innovative sampling solutions are sought that integrate with limited burden into or onto personal protective equipment (PPE) while eliminating the need for an externally powered air sampler, maintenance, and the overall logistic burden associated with processing the sample matrix from deployment to use in fielded biological detectors. Potential solutions may include novel media (e.g., gels or adsorbent fabrics), passive concentrating technology, or integrated into / onto current fielded respiratory systems. The goal is to develop a lower maintenance, lower profile, and lighter weight biological air sample matrix add on / passive flow device for end user exposure surveillance. Current technology turnaround time to gather actionable knowledge of the presence of a biological in the air is far too long. This technology developed would reduce that time and reduce the burden of actively gathering an air sample. Potential operational uses may include prolonged entry into immediately dangerous to life and health (IDLH) atmospheres or unknown CBRN environments.

PHASE I: Design and develop passive, IPE integrated biological sampling technology / matrices that are effective in passively capturing particles present in the air and offer significant improvements in the logistical burden associated with the current air sampling technologies. Demonstrate feasibility in application, integration in COTS prep kits and archive capable and ability to have biological material capture in/on the material. Identify key performance efficiency parameters and test criteria relevant to use and follow on testing with one biological test platform. Establish test setup and procedures to assess and validate proposed approach. Fabricate physical model and conduct bench top testing to characterize the performance of the proposed solution(s) to include but not limited to the following, where applicable to the proposed technology: adsorption capacity, efficiency of capture rate, and use in diagnostic platform detailing limitations (if any), logistic requirements, inhibition by-products, and efficiency under relevant temperature/humidity conditions.

PHASE II: Refine and optimize Phase I model to capture protein/toxin and bacteria capacity and performance. Perform follow-on bench top evaluations to verify improvements made to the basic enabling technology. Modify test setup and improve test procedures as required. Develop functional prototype by incorporating enabling technology into a suitable test bed (e.g., M50 mask or UIPE ensemble). This technology should be non-invasive to any PPE and capable of being donned / doffed while fully protected. Characterize test bed performance under an operational relevant range of external environmental (temperature/humidity) conditions. Based on results obtained, implement necessary refinements to the scalable test bed model.

In preparation for Phase III, transfer functional prototype to CCDC CBC for independent benchtop verification and validation. Training of Government personnel will be provided by the performer in the proper use of the prototype. Performer will offer test support including addressing technical issues.

PHASE III DUAL USE APPLICATIONS: Fully integrate solution into a full-scale, fully-functional prototype. Demonstrate ability of the technology to be incorporated into an end user donned ensemble through modification of an existing systems. Expand applications to other commercial detectors.
Transfer fully-functional prototype to CCDC CBC for independent verification and validation in aerosol chamber. Training of Government personnel will be provided by the performer in the proper use of the prototype. Performer will offer test support including addressing technical issues.

REFERENCES:
1. Biomarkers: Potential Uses and Limitations

KEYWORDS: Biological Sampler, Passive, Integrated, Low burden
TITLE: Indicator Chemicals for In-theater Inkjet Assay Production

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Chem Bio Defense

OBJECTIVE: Develop, demonstrate, validate, and produce indicator reagents to enable on-demand, in-theater printing of low-user-burden chemical and biological threat detection and identification assays on COTS inkjet printers.

DESCRIPTION: Low-burden, inexpensive, and eye-readable assays such as M8 paper, litmus paper, and assays for protein or ATP (adenosine triphosphate) are common first line tests performed on an unknown in order to determine if it is innocuous or a potential threat. Inkjet printing can be used to produce these types of color-change assays at the point of need by replacing standard ink cartridges with indicator reagent cartridges. On-demand printing can also be used to produce purpose-built assays tailored to the task at hand by selecting relevant indicators to combine together on assays customized in size and format. Inkjet printing also permits the deposition of indicators on a range of substrates including fabrics and adhesive-backed materials to create custom contamination and exposure indicators for personnel, vehicles, and fixed or temporary structures, expanding an intuitive sensing modality (observable color change) to multiple concepts of operation and employment.

To enable these capabilities, additional development is required to formulate more color-changing indicators for inkjet printing. The availability of a wide range of chemical indicators which respond to relevant threats with high-contrast color changes works towards the goal of a comprehensive chemical and biological sensing capability. Inexpensive, low-burden, and low-false-alarm threat awareness is essential for maintaining lethality and achieving mission success when operating in a chemical or biological environment. Formulated indicators should be compatible with COTS (commercial-off-the-shelf) inkjet printers using aqueous ink systems, and should be stable, stored in cartridges, for at least two years. Initial printed colors of the indicators should be highly consistent and compatible with a wide range of COTS inkjet printing substrates.

PHASE I: Conduct a feasibility study of indicator chemicals useful against chemical and/or biological targets, demonstrating methods to formulate at least four of these indicators for inkjet printing. Propose and describe concepts of operation for the deployment sensing capability using on-demand printing of indicators and estimate system costs. These formulated indicators, a report on their development, and concept-of-employment descriptions will be the deliverables from this phase.

PHASE II: Mature concepts into a prototype system: Identify and prepare a panel of indicators to treat major classes of TIC/TIM/CWA (toxic industrial chemicals / toxic industrial materials / chemical warfare agent) materials. Formulate these indicators for printing, optimizing printed optical density, consistency, and storage life. Perform storage studies and characterize responses across a range of printing substrates. Develop cost information for production and sustainment of printing systems using these indicators. Develop a capability demonstration based on these materials and participate in a field trial, operational analysis event, or other Warfighter-attended event to obtain direct user feedback. These formulated indicators, a report on their development, and a report on a field demonstration activity will be the deliverables from this phase.

PHASE III DUAL USE APPLICATIONS: Refine and validate the prototype system. In addition, working with appropriate partners, identify or develop indicators against novel and emerging threats and add these targets to the system. Establish manufacturing processes and transition to commercial and military customers.
Phase III Dual-Use Applications

Military needs alone will not likely be a sole driver for this technology or approach. However, there are a variety of potential non-military users which include various aspects of chemical manufacturing (leak detection, process monitoring and validation, chemical hygiene), civilian first responders, food processing, and biomaterials research and production. Therefore the proposed concept of operation and commercialization plans should consider nonmilitary markets.

REFERENCES:


KEYWORDS: Chemical, Biological, Sensing, Maneuver Support, Expeditionary, On-Demand Production, Low-Burden
TITLE: Programmable AC/DC Lithium-ion Battery for High-voltage Applications

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: Reconfigurable, software programmable AC/DC Lithium-ion battery modules and packs capable of supporting high-voltage ground vehicle and robotic applications.

DESCRIPTION: Developing next generation electric based ground vehicles will require a battery module in the 24 V to 60 V range that can be assembled into a high voltage pack up to 1000V. Emerging military hybrid vehicle platforms, such as the Robotic Combat Vehicle (RCV) or Optionally Manned Fighting Vehicle (OMFV), will require high-voltage battery packs with the following expected characteristics: nominal voltage from 450 to 600 V, continuous power capability of 250 to 400 kW, and 25 to 100 kWh installed energy. Currently, in an electric- or hybrid-electric vehicle system, power electronics are required to convert between all of the different AC and DC voltages required by the various components, such as the AC motors and DC battery. These electronics include DC-DC converters, AC-DC rectifiers, DC-AC inverters, chargers, and motor drive controllers, and each extra component contributes to power losses and packaging inefficiencies. In the solar panel sector, AC batteries which are composed of energy storage coupled with micro-inverters are available as an alternative to having a large external DC-AC inverter to connect the DC energy storage source to the AC loads and provide enhanced space & power efficiencies. Accordingly, innovative solutions must be developed and demonstrated for vehicle high-voltage mobility batteries which will allow for a fully reconfigurable & software programmable AC/DC Lithium-ion battery, which can source and sink various DC & AC voltages with higher power, thermal, & packaging efficiency. Technology developed shall allow for direct charging of the AC/DC Lithium-ion battery off of a wide variety of both DC (ex: 28V, 50V, etc.) and AC sources (ex: 120VAC, 480VAC, etc.). The AC/DC Lithium-ion battery shall also allow for direct connection to an electric motor, or other AC loads, without need for an inverter or motor controller (single & three-phase AC). Technology developed to allow AC/DC variable operation should be fully integral to the battery and shall consider balancing/equalization, reliability, high-voltage safety, and capacity utilization. Technology developed should be scalable to 24V – 60V modules composed of a few cells to a few hundred cells, and should support pack configurations up to 1000V.

PHASE I: Identify and determine the engineering, technology, and embedded hardware and software needed to develop this concept. Drawings showing realistic designs based on engineering studies are expected deliverables. Additionally, modeling and simulation to show projected performance and Ah capacity of the AC/DC Lithium-ion battery modules & pack designed in this phase is expected. Cost analysis projections should also be performed to determine the cost premium between a standard battery system with external conversion electronics and an AC/DC Lithium-ion battery pack (<20% increase in overall product cost). A bill of materials and volume part costs for the Phase I design should also be developed. This phase also needs to address the challenges identified in the above description, including scaling to higher voltage packs.

PHASE II: Develop and integrate prototype embedded hardware and software to create AC/DC Lithium-ion battery modules and packs for high-voltage mobility applications. The AC/DC Lithium-ion battery modules shall interconnect to support series and parallel configurations in a battery pack and shall meet the following minimum requirements: 1.5 – 4 kWh, 10 – 25 liters, <60 kg, 20 – 25 kW peak power, 24 – 60 V, 5 to 10 C-rate, and -30 to 60°C operation with thermal management. Each module shall have a digital communication interface that supports at a minimum high-speed ISO 11898 CAN communication, as well as any other isolated digital communication protocols (e.g. SPI) necessary for operation of the battery module in a high voltage battery pack. Testing should be performed on AC/DC Lithium-ion battery modules and packs to demonstrate operation, performance, and Ah-capacity. Cost analysis should
also be performed on the finalized product to determine the cost premium between a standard battery system with external conversion electronics and an AC/DC Lithium-ion battery pack (<20% increase in overall product cost). A bill of materials and volume part costs for the Phase II design should also be developed. Deliverables include electrical drawings and technical specifications, software, M&S and test results, and one AC/DC Lithium-ion battery pack (nominal voltage from 450 to 600 V) composed of reconfigurable, programmable AC/DC Lithium-ion battery modules. The pack battery management system (BMS) shall have at a minimum two SAE J1939 interfaces to support communication to the vehicle.

PHASE III DUAL USE APPLICATIONS: This phase will begin installation of the AC/DC Lithium-ion battery packs using the solutions developed in Phase II on selected vehicle platforms (military, commercial EV/HEV, etc.) and will also focus on integration of Phase II embedded hardware and software technologies into the production processes of current Li-ion batteries.

REFERENCES:

KEYWORDS: Lithium-ion, batteries, power, energy, battery management systems, CAN bus, low-voltage, high-voltage
TITLE: Retractable Gunner Restraints

OBJECTIVE: The retractable gunner restraint system will restrain and protect gunners in various vehicles from high energy events by rapidly retracting them back into the vehicle during typical injurious scenarios like Vehicle Borne Improvised Explosive Devices (VBIED), underbody blast, top/bottom attacks, crash, and rollover events.

DESCRIPTION: Occupants in the gunner position are often in non-traditional seats that either provide ineffective or no restraints. The restraints are often constrictive, preventing them from efficiently performing their mission leading them to not be used. Additionally, the restraints have no functionality to safely pull the occupant back into the vehicle leaving them vulnerable to injury during high energy events. A new retractable gunner restraint system shall be internally mounted in the vehicle and must restrain and protect Soldiers within the central 90th percentile while fully encumbered. The system may interface with the Improved Outer Tactical Vest (IOTV), but this feature is not required. The system shall react and retract rapidly enough to provide protection during events including, but not limited to: underbody blast, crash, rollover, top/bottom attack, and VBIED without inducing injury to the occupant due to the retraction.

PHASE I: Define and determine the technical feasibility of developing a retractable gunner restraint system that is lightweight, durable, and will protect the occupants during high energy events without inducing injury due to the retraction. The restraints must be capable of containing the central 90th percentile Soldier population while fully encumbered and durable enough to handle the rugged conditions encountered by ground vehicles. System must be FMVSS 207/210 compliant. The system must, at a minimum, meet FMVSS 208 Injury Criteria (additional injury criteria will be provided once on contract) for the following tests: drop tower testing (up to 350g half sine pulse, delta V 10 m/s) and FMVSS 213 Child Seat Corridor Sled Testing (additional testing criteria will be provided once on contract).

PHASE II: Develop and test at least 5 prototype restraint systems that can protect and contain the central 90th percentile Soldier population during high energy events including, but not limited to, blast, crash, rollover, and VBIED. Based on the findings in Phase I, refine the concept, develop a detailed design, and fabricate simple prototype systems for proof of concept. Identify steps necessary for fully developing a commercially viable restraint system. The system shall by FMVSS 207/210 compliant. The system must, at a minimum, meet FMVSS 208 Injury Criteria (additional injury criteria will be provided once on contract) for the following tests: drop tower testing (up to 350g half sine pulse, delta V 10 m/s) and FMVSS 213 Child Seat Corridor Sled Testing (additional testing criteria will be provided once on contract).

PHASE III DUAL USE APPLICATIONS: System can be commercialized to PD LTV applicable variants (M1151A1, M1152A1, and M1165A1) in addition to NGCV and any fielded ground vehicle with an open gunner position. Additional commercialization to private sector vehicles with exposed occupants like first responder vehicles, garbage trucks, etc.

REFERENCES:
1. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA608804
KEYWORDS: Restraints, gunner, retractor, underbody blast, crash, rollover, vehicle borne improvised explosive device (VBIED), top/bottom attack, accommodate and protect, central 90th percentile Soldier population
TITLE: Advanced Heavy-Duty Diesel Engine Piston

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: Design, develop, and manufacture a heavy-duty diesel engine piston capable of withstanding the severe thermal stresses from a localized, periodic surface heat flux exceeding 20 MW/m² at frequencies up to 40 Hz, with limited back-side cooling.

DESCRIPTION: Recent commercial industry trends in internal combustion (IC) engine development have focused on reducing air pollutants and fuel consumption in order to comply with environmental regulatory requirements concerning greenhouse gas emissions. Accordingly, diesel engine manufacturers have renewed their efforts to increase engine efficiency from the current status of 45% brake thermal efficiency (BTE) towards the theoretical limit of approximately 65% BTE. A pair of recent technical papers by Cummins, Inc. outlines the potential efficiency gains achieved through improvements in heat transfer reduction, friction reduction, lubricant viscosity, parasitic losses (e.g. oil and water pumps), turbomachinery efficiency, engine downsampling, exhaust aftertreatment optimization, and last but not least, engine combustion system optimization (SAE 2013-01-2421 and SAE 2019-01-0247). This topic focuses on increasing the thermal efficiency of a 120mm-140mm bore size diesel engine through optimization of the combustion system and the resultant piston heat transfer.

Engine combustion system developments include trends towards higher compression ratios, higher in-cylinder pressures (greater than 300 bar), piston bowl geometry optimization, and increased fuel injector flow rates to enable shorter combustion durations. As the combustion duration shortens and compression ratio increases, the cylinder pressure and temperature will necessarily increase, resulting in gas-side piston surface temperatures that exceed the material temperature limit (~500°C) of traditional steel piston alloys, such as 4140 steel. Another consideration when pursuing these technology developments is increased piston heat transfer. Shorter combustion durations necessitate higher localized heat fluxes (greater than 20 MW/m²) on the piston as the hot flame impinges on the piston bowl surfaces.

Whereas the engine designs of commercial vehicles are heavily weighted towards achieving low emissions and good fuel economy, these attributes are less important in the design of military vehicles. Combat vehicle engines in particular should have high power density and low heat rejection, because the propulsion system competes with the vehicle’s functional systems for the total volume under armor.

Thus, future combat engines designed for low heat rejection (< 0.5 kW/kW) and high output (90 bhp/L) share some of the design limits of a commercial engine, one of which is piston surface temperature. Temperatures above critical material property limits can result in reduced engine life and piston failure. Optimization of piston design for such low rejection, high power density engines while maintaining acceptable piston surface temperature is a critical step in the engine development process.

The purpose of this topic is develop an advanced, heavy-duty diesel engine piston optimized for continuous, high-load operation at desert-ambient operating conditions for military ground combat vehicles. Proposals should aim to increase the peak cylinder pressure limit to 275 bar and the surface temperature limit to 600 °C, or propose technologies to reduce surface temperatures at equivalent thermal loading. The application of thermal barrier coatings to the piston crown will not be considered for this topic.

PHASE I: Conduct the engineering analysis to support the design and development of a prototype 120mm-140mm bore size piston capable of sustained operation at high-load conditions in a direct-injection, heavy-duty diesel engine. Determine the required thermal and mechanical properties and
perform laboratory testing to support the selection of an appropriate material for the piston. Identify unique manufacturing requirements and conduct prototyping of a conceptual piston to demonstrate feasibility of the proposed piston technology.

PHASE II: Manufacture and test an advanced heavy-duty diesel piston prototype enabling higher combustion temperatures and pressures without compromising piston strength or durability. Develop a CAD model and engineering drawings with tolerances, surface finishes, anti-corrosion and skirt (friction) coatings, and manufacturing instructions. Develop quality inspection and approval process requirements for the prototype piston. Required deliverables include an engine test report, piston temperature analysis, CAD model, drawings, and delivery of a prototype piston to the Government’s specification.

PHASE III DUAL USE APPLICATIONS: Further develop an advanced diesel engine piston for use in a commercial engine, and demonstrate the piston development in a multi-cylinder engine. It is envisioned that this technology would benefit high-efficiency, future commercial diesel engines as well, especially in vehicles demonstrating engine brake thermal efficiency of 50%.

REFERENCES:

KEYWORDS: Internal combustion engine, Piston, Heavy-duty diesel, High-temperature alloy
TITLE: Rapid Terrain/Map Generation for Robotic and Autonomous Vehicle Simulations

RT&L FOCUS AREA(S): Autonomy
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: The objective is the rapid generation of Real World Landscapes (Geo Specific) with features (e.g. ground material, bushes/trees, roads, buildings) for Unreal Engine 4 using GIS Data (Digital elevation model), LIDAR data, satellite images, Photogrammetry so that the Landscape map in Unreal Engine 4 is high fidelity enough to use for Robotic and Autonomous Vehicle Simulations.

DESCRIPTION: The Ground Vehicle System Center (GVSC) performs research using interactive ground vehicle simulations akin to realistic video games. In these simulations we measure the performance of soldiers at tasks such as planning and driving. The GVSC interactive ground vehicle simulations are also used for the development of robotic and autonomous systems and the evaluation of these autonomous driving algorithms. It presently takes months to create a geospecific terrain model for use in the simulation largely due to the quantity of area that needs manual creation and touch-up. This is primarily due to our unique requirement for high visual quality (and rendering performance) but only landmark level accuracy for geotypical features.

We are using Unreal Engine for rendering our camera views which put some requirements on the structure of the data that we use. The digital elevation model of the terrain surface is a rectangular grid of altitudes in UTM-style coordinate system. Accompanying the elevation data is any number of layers which we use, one each, for grass, dirt, road, etc. Each layer has a single graphical “material” which affects how it drawn and a blend weight image (of the same dimensions as the elevation data) which represents the “weight” of coverage of that material on that part of the map. On top of this terrain surface we place 3D polygon models of bushes, trees, fences, rocks, buildings, etc. Outside of particular areas of interest, we repeatedly use the same models as we only care about the location of a tree not if every branch is in the right place.

Specifically we model the terrain type and elevation with a post spacing of .5m-1.0m which we cover with “typical” imagery of grass, dirt, asphalt, etc. at <1cm/pixel resolution. In addition to the re-use of 3D models, large non-navigable areas outside our areas of interest, such as forests and buildings, will modeled as solid volumes with imagery on the sides. While these models don’t necessarily visually match the real objects in the area they must be located in the exact spots as we sometimes replay position data recorded from real vehicles.

Existing solutions for generating this data are either too detailed, preventing rendering at interactive speeds, too specific, or accurate only when viewed from a distance. A complicating factor is that we are viewing the scene from the ground at a height of 1m-4m which is close to perpendicular to the viewpoint of commonly available imagery. Aerial imagery looks blurry when shown from a viewpoint that close. This difference in viewing angle leads to a deficiency in 3D model generation algorithms that use aerial imagery (e.g. Google Maps 3D view). The resulting models are misshapen, misaligned, and of insufficient detail when viewed up close and from the ground but otherwise look fine when viewed from above. A secondary failing of areal imagery in our use case is that it is blind to the area under a tree. Drawing a tree canopy on the ground surface is clearly wrong when viewed from low angles. While we can never truly know what is under the tree we need to back fill those areas with plausible terrain.

There is a lot of existing research into terrain classification/segmentation which we can use to generate terrain layers. However, these algorithms are unable to look under the trees where we don’t have data yet but need plausible terrain. Classifying the terrain is also important from a driving perspective. While we...
don’t need to model soil properties, our simplified tire models need to know, broadly, if we’re on asphalt vs. dirt vs. grass. We also don’t need to model geometric features as small as a pot hole.

A possible solution to filling in the gaps is inpainting or image healing, akin to Photoshop, but such tools require manual intervention. There is no present tool to automatically identify obscured areas in the terrain and fill them in with plausible data. In addition, some of these areas, such as a single tree, will need to be identified and replaced with a 3D model that is not part of the terrain.

This SBIR is seeking innovative solutions to the development of realistic terrain models with dimensions up to 8km x 8km with rectangular regions of 5-10 km² being typical. The solution should be standalone software which accepts as input elevation data and satellite imagery and then generates a visually rich terrain suitable for use in the Unreal Engine. The solution must be highly automated employing classification to generate specific terrain types to include roads, fields, forests, water features and buildings as well as detect, remove, and inpaint the terrain covered by individual trees, cars, people, etc. The solution must provide methods for human-guided interpretation and classification of areas that are ambiguous by means of selective labeling and or morphing. The tool shall allow an adept user to convert convincingly real terrain at a rate of 1 km²/hr.

PHASE I: The vendor shall deliver a prototype system demonstrating the classification/inpainting of terrain. From a 2-D elevation data (height-map) (.5m/px resolution) and aerial imagery aligned to the elevation data, classify/segment the image into terrain types; one lossless greyscale image per type (png, tiff, etc). The input imagery may be at a different resolution than the elevation data with the edges of the data aligned. The output images must be pixel aligned with the elevation data, where white represents 100% coverage or confidence.

Considering the low resolution, multiple terrain types for a given spot are possible, for example a patch of thin grass with dirt showing through could be marked as 50% each on their respective layers. Adjusting the weights for improved appearance encouraged. All-or-none rounding to create hard edges is discouraged. (We acknowledge that this is sub-optimal for paved roads.)

For certain types representing covered areas, the unknown area underneath will be inpainted with a different terrain type surmised from the surrounding area and similar features elsewhere. For example, the area under a tree will be filled in with grass, dirt, etc. or a combination.

The algorithm should also indicate areas that may need to be represented with a new terrain type or otherwise require manual intervention. A user shall have access to intermediate products which can then be adjusted and the following stages of the process re-run.

We expect that solutions will combine and modify existing image processing and classification tools to accomplish the goals. Developing a custom neural net is outside of the scope for Phase I. The essence of Phase I is the interaction between the classifier, the inpaifter, and the user. Although we discuss a segmentation/inpainting process, other classifying/fill-in-the-gaps algorithms along with other pre/post processing steps is permitted.

PHASE II: The vendor shall deliver a plugin for Unreal Editor which will import the elevation data and aerial imagery, classify and heal it, and generate terrain elevation model, terrain type layers, unreal rendering blueprints, etc. as necessary to represent the terrain. As part of this process, a user may manually override classification in certain areas and the software must rework the final output based on the changes.
For certain movable objects such as people, vehicles will be erased. For areas that represent large objects (trees, rocks, road signs), it will place a representative model in the scene. These 3D models will be user provided but the software must automate the placement.

For areas that represent impassible terrain (forests, buildings), a 3D model representing the footprint of the area extruded to a best-guess height will be generated. (This model will be used by an artist as a basis for detailed model which is outside the scope of this project.).

Hard edged roads shall be detected, erased, and replaced with a polygonal model. Physics material properties may be provided by the user and if so, the software will attach them to the corresponding terrain. (Software does not need to understand what these represent.)

PHASE III DUAL USE APPLICATIONS: Military application is for the development and testing of automated vehicles or vehicle functions which are highly dependent on a modeling and simulation environments with geospecific high fidelity terrain/maps that can be generated rapidly. It is for the development and testing of such systems. The U.S. Army GVSC has a critical need for geospecific high fidelity terrain/maps. Commercial application is in the automated driving technology testing and assessment. This applies to both the automotive industry as well as military OEMs and suppliers.

REFERENCES:

KEYWORDS: Modeling & Simulation, Autonomous Systems, 3D Terrain, three-dimensional models, geospatial intelligence, Digital Terrain Models, Digital Surface Model
A20-130  TITILE: Mobile Medic Interior Seating

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Materials

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The mobile medic interior seating will allow medics to remain safely seated and restrained while enabling them to travel along and around a litter to provide necessary medical care to a wounded Soldier. This can be integrated into any medical vehicle and adapted for usage beyond medics to enable Soldiers to be mobile within the vehicle to perform various missions while maintaining occupant protection. The seating will protect medics from high energy events by rapidly retracting them back into the vehicle during typical injurious scenarios like Vehicle Borne Improvised Explosive Devices (VBIED), underbody blast, top/bottom attacks, crash, and rollover events.

DESCRIPTION: Occupants in the medic position are often not seated or not restrained properly in order to provide the necessary medical care to an injured Soldier. The medic’s seat is typically in a fixed position at the head of the litter and does not allow them to move along the litter to assess the injury and provide care. A new mobile medic seat will travel along and around a litter while allowing them to remain seated and restrained. The system shall be internally mounted in the vehicle and be able to be integrated into an existing vehicle or litter system. The seating system shall accommodate and protect the central 90th percentile Soldier while encumbered. The system shall endure and provide protection during events including, but not limited to: underbody blast, top/bottom attack, crash, and rollover events.

PHASE I: Define and determine the technical feasibility of developing a mobile medic interior seating system that is lightweight, durable, and will protect the occupants during high energy events while allowing them to be mobile within the vehicle. The system must be capable of containing the central 90th percentile Soldier population while encumbered and durable enough to handle the rugged conditions encountered by ground vehicles. System must be FMVSS 207/210 compliant. The system must, at a minimum, meet FMVSS 208 Injury Criteria (additional Injury Criteria will be provided once on contract) for the following tests: drop tower testing (up to 350g half sine pulse, delta V 10 m/s) and FMVSS Child Seat Corridor Sled Testing (additional testing criteria will be provided once on contract).

PHASE II: Develop and test at least 5 prototype systems that can protect and accommodate the central 90th percentile Soldiers during high energy events including, but not limited to: blast, crash, rollover, and VBIED. Based on the findings in Phase I, refine the concept, develop a detailed design, and fabricate simple prototype systems for proof of concept. Identify steps necessary for fully developing a commercially viable system. The system shall be FMVSS 207/210 compliant. The system must, at a minimum, meet FMVSS 208 Injury Criteria (additional Injury Criteria will be provided once on contract) for the following tests: drop tower testing (up to 350g half sine pulse, delta V 10 m/s) and FMVSS 213 Child Seat Corridor Sled Testing.

PHASE III DUAL USE APPLICATIONS: System can be commercialized to AMPV, in addition to any NGCV or fielded vehicle with a medic position or mission need for an occupant to be mobile.
Additional commercialization to private sector vehicles with a need for a mobile occupant like first responder vehicles (ambulance, fire, etc.).

REFERENCES:
1. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA608804

KEYWORDS: Medic, litter, seats, underbody blast, crash, rollover, vehicle borne improvised explosive device (VBIED), top/bottom attack, accommodate and protect, central 90th percentile Soldier population
A20-131

TITLE: Radio Network Model Plugin for Unreal Engine Vehicle Simulation

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: The objective is to develop a plugin for Unreal Engine 4 that can be used to simulate a wireless radio network using the Unreal Engine environment (e.g., Landscape Map, weather...) that supports the same conditions as in the real world (e.g., line of distance interference) for evaluation of robotic and autonomous systems (RAS) operating in Manned-Unmanned Teaming (MUMT) scenarios.

DESCRIPTION: In order to appropriately develop and test autonomy software/algorithms for Army ground vehicles, the Army needs to use modeling and simulation (M&S) to look at all the different conditions and scenarios that the autonomy software will encounter. A key component of robotic and autonomous systems (RAS) operating in Manned-Unmanned Teaming (MUMT) is the Army wireless radio data network.

The goal of this SBIR topic is to provide the Army with a way to develop and test RAS with a correct representation of the Army wireless radio data network using M&S that includes the 3D terrain with features (e.g., ground material, bushes/trees, roads, buildings) and weather conditions. The simulation should support being able to model the entire network, antennas, and military wireless radios so GVSC can evaluate how the wireless radio would operate in a military network during virtual military experiment (e.g., autonomous vehicle convoy, manned unmanned vehicle teaming) using Unreal Engine simulation vs how they would operate in real world with line of distance interference.

Army data networks need to work in harsh ever-changing conditions. They can do so through sophisticated radio technologies, though they are not always successful. The Army needs a simulation capability that can predict failures (i.e., what is the probability of a packet reaching its destination) in real time during the execution of simulation. Full information of the terrain and weather as well as with respect to all radio sources will be available in real time (or can be pre-calculated as needed). It is expected that a continually updated channel model will be created taking into account relevant aspects, considering multipath, scatter, Doppler, fading models, diffraction, etc., as appropriate. Models of radios used by the Army such as the Persistent Systems MPU5 will use this channel model to determine the likelihood of packet loss, as well as latency estimates.

This SBIR is seeking innovative solutions to the development of Radio Network Model as plugin for Unreal Engine. The solution should be able to use the 3D terrain with features along with the simulation’s weather conditions in Unreal Engine to determine how the radio and radio network would be affected. The solution should allow the simulation user to attach the radio to vehicles in Unreal Engine simulation and dynamically be able to handle the movement of these vehicles and the affect to the radio network.

PHASE I: In Phase I the vendor shall develop an architecture and describe how it will meet the goal of creating Radio Network Model Plugin for Unreal Engine Vehicle Simulation. The vendor shall demonstrate using a simplified model of a channel as well as of a radio as expected as the result of the Phase I effort. These models will utilize a Government provided Unreal terrain database to extract relevant information to make this feasible.

PHASE II: In Phase II the vendor shall fully develop the architecture started in Phase I. The expected deliverable would be a channel model as an Unreal Engine plugin that models enough to be useful to the radio models downstream. To build an effective model, additional data may be added to the terrain. If so, these additions to the 3D terrain will be identified by the offeror along with how this would be
supported. The product shall include the ability through the plugin to attach the simulated radio to the simulated vehicles in Unreal Engine. The product shall demonstrate modularity by including at least one radio model with the capability provided via an editor in Unreal Engine or via a configuration file for Army personnel to be able to create additional radio models. The product shall demonstrate ability to provide the simulate radio network during an Unreal Engine vehicle simulation scenario. If feasible, captured data of the MPU5 radio’s performance in the terrain modeled by the Unreal database will be provided for the purposes of validation of the model.

PHASE III DUAL USE APPLICATIONS: Military application is for the development and testing of robotic and autonomous vehicles systems in manned unmanned teaming which are highly dependent on a modeling and simulation environments with a simulated radio network. A product modeling radio networks with dynamic players using them would be useful for more than just Army Ground Vehicle simulations. The Unreal Engine is poised to be used in many commercial simulation, not just games. These commercial simulations include, but are not limited to, self-driving vehicles (and their networks), emergency/natural disaster simulations, vehicle network simulations, as well as mobile phone simulations.

REFERENCES:

KEYWORDS: Modeling & Simulation, Radio Channel Modeling, Radio Simulation, Unreal Engine
TITLE: Lightweight Robotic Mule

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: A robotic personal mobility device that can carry a soldier or that they can carry.

DESCRIPTION: Off road terrain poses a continual challenge to military movement. Coupled with the heavy loads that dismounted soldiers are required to carry, resupply robots such as the Squad Machine Equipment Transport (SMET) can provide a needed capability for the US Army and USMC, but struggle with narrow trails and urban environments. The goal of this topic is to overcome current SMET mobility limitations by expanding the terrain that an SMET robot can negotiate while intrinsically improving the transportability of the system. It is anticipated that a lightweight robotic mule will improve the mobility of the SMET through narrow trails and urban environments while being easier and lighter to maneuver. The goal is to be able to maneuver through a standard door opening, while being light enough unloaded for one-man lift.

PHASE I: Develop a mechanical design to support additional weight while negotiating a narrow door opening or narrow trail and balancing dynamically. The mechanism must be easily packed and transported by hand into another vehicle. Demonstrate the mechanism feasibility in a Computer Aided Design (CAD) environment such as SolidWorks or equivalent. The mechanism must be suitable for one-man lift, with weight not to exceed 20kg (Threshold) or 15kg (Objective). The robot should be able to negotiate a standard door opening while fully loaded.

PHASE II: Prototype the mechanical design developed in Phase I and demonstrate it on a soldier following mission, such as an SMET demonstration. The system should support between 100kg (Threshold) and 150kg (Objective) of payload. The system should provide soldier following capability and be able to perform with or without the operator on board. The system should control balance of the vehicle, while avoiding obstacles, and negotiating narrow urban or off-road terrain. The system shall be able to navigate through a standard handicap accessible door width, 80 cm (threshold) to 50 cm (objective). The top speed on flat terrain should be 5m/s (Threshold) to 7m/s (Objective) with a range of 15 miles (Threshold) to 20 miles (Objective). The objective terrain is a standard nature trail in a boreal forest, which may have a few roots and rocks but free from climbing obstacles.

PHASE III DUAL USE APPLICATIONS: This topic is developed in direct connection to several Army programs, e.g. Soldier Machine Equipment Transport (S-MET). The civilian sector would also significantly benefit from the developed technology for use in urban transportation applications. The benefits of this development would be inherently safe autonomy in and around people. This type of vehicle could be optionally manned, it can carry you, or you can carry it. This topic addresses the “last mile” problem which has dual-use applications in industry.

REFERENCES:

KEYWORDS: robotics, path planning, personal mobility, soldier load
TITLE: Innovative Technologies for Precision Timing of Onboard Munition Navigation Systems

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a technology for precision time in the onboard navigation systems of precision guided munitions (PGM) for purposes of navigation and to assist with post launch acquisition and tracking of Global Positioning System (GPS) or alternate navigation sources (ALT-NAV).

DESCRIPTION: The U.S. Army has a need for precision time in the onboard navigation systems of precision guided munitions (PGM), such as Excalibur or Precision Guidance Kit, for purposes of navigation and to assist with post launch acquisition and tracking of Global Positioning System (GPS) or alternate navigation sources (ALT-NAV). Current PGM systems can experience relatively large errors in timekeeping (seconds) during the gun launch, due to the shock of the 12,000+g loads experienced in the gun barrel. The resultant time uncertainty increases the risk to acquiring GPS or ALT-NAV sources in challenged environments, makes the PGM entirely reliant on successful acquisition of a trusted time source (eg. GPS) to reset the clock post-gun-launch. Currently available alternatives are either less survivable in the gun environment, do not meet size (less than 1 cubic cm), weight (less than 1 ounce), and power constraints (less than 1 watt) (SWaP), or would require too much time to temperature stabilize pre-launch. Operating temperatures range from -40 degrees to +160 degrees Fahrenheit. Technologies that have the potential to be significantly more precise and less susceptible to time shifts during gun launch, enabling the keeping of accurate time (less than 10 ms) through the gun environment and enabling improved acquisition of GPS and ALT-NAV sources without any adverse SWaP impacts. Potential beneficial applications extend beyond the PGM environment, since these devices could prove to have positive SWaP implications without compromising performance. The end result of this effort would be a technology that is fully performance characterized and proven in the extreme gun environments, and ready for integration in munitions such as Excalibur, Precision Guidance Kit - Anti-Jam (PGK-AJ) and Hypervelocity Projectile (HVP).

PHASE I: Phase I will consist of an engineering study that will result in laboratory bench top prototypes demonstrating the performance requirements in a laboratory setting. The main focus of the testing will be to demonstrate the timing capability, with an engineering assessment of performance in the actual weapon firing environment. A final report will document all results and analyses. The Phase I Option, if exercised will develop the system performance specification documenting system requirements and test methods.

PHASE II: Phase II will further mature the technology to meet all requirements in the system requirements specification, with a final demonstration in a relevant environment such as gun launch. Actual gun launch tests will be performed at a government facility with contractor support.

PHASE III DUAL USE APPLICATIONS: Phase III will integrate and qualify the technology in a full-up munition in preparation for transition to production.
REFERENCES:

NOTE: The reference to any particular company or product is for information only and not an endorsement of that company or their technology.

KEYWORDS: precision timing, precision munitions, guidance and navigation, PNT, GPS, atomic clock, oscillator
TITLE: Innovative and Intelligent Standoff Detection Algorithm

RT&L FOCUS AREA(S): Autonomy
TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop innovative and intelligent Standoff Detection Algorithms for remotely operated explosive hazard detection systems.

DESCRIPTION: The U.S. Army is looking to improve the detection capabilities for robotic explosive hazard detection systems. The existing system has demonstrated success leveraging existing algorithms from the handheld detector that it utilizes. However, due to the additional processing power on board the platform and ability to mount sensors to monitor the detector itself, there is potential to develop algorithms to enhance the signal coming from the detector(s). Without the critical size weight and power restrictions of a handheld device, the robotic platform has the ability to process additional data and integrate more inputs. There are opportunities to implement volumetric analysis, enhanced visualization, augmented reality, and machine learning or artificial intelligence to improve the detection capabilities (by learning from past experiences), intelligently integrate signals from multiple sensors (such as ground penetrating radar, pulsed induction, and electromagnetic induction, and relay of that information to the user. Advances in detection algorithms beyond the existing performance can improve the detection capability, increasing the survivability of the system and most importantly the warfighter. The end result of this effort will be mature algorithms that can undergo testing for detection performance and human factors. This effort will help advance the maturation of a solution to be able to rapidly field a capability.

PHASE I: Phase I will result in laboratory and field demonstrations of the prototype algorithm(s) to test the ability to meet requirements. Simulated hazards will be used to test the system. The primary objective of these tests will be to demonstrate the detection and processing speed as it relates to false vs true readings. The Phase I Option, if awarded, will develop the system specification based on results of the Phase I demo, which will be used to drive requirements for Phase II.

PHASE II: Phase II will fully mature the algorithms to a robustness required to demonstrate in a simulated operational environment, and integrated into the demonstration platform. Phase II will culminate with an operational demonstration at a government facility using a combination of simulated and actual hazards.

PHASE III DUAL USE APPLICATIONS: Phase III will consist of full qualification of the technology in the host system in preparation for transition to fielding.

REFERENCES:


KEYWORDS: hazard detection, mine detection, explosive detection, robotics, tele-operate, mine detector, hand held detector, UXO, metal detector, trip wire.
TITLE: Low-Cost Gamma Dose Rate Technology for Military Operations

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Nuclear

OBJECTIVE: Develop and demonstrate very low-cost gamma dose rate sensors that are applicable for the wide range of military operations: very rugged, able to work in all military environments, nuclear survivable, and low SWAP (size, weight, and power).

DESCRIPTION: The United States Department of Defense (DoD) needs the ability to measure the dose rate throughout its range of operations. Standard radiation detection requirements for the military includes accurate gamma dose rate measures through the entire range of operations (from background to 100 Gy/hr), ability to maintain accuracy over a wide temperature range (-50 °C to 55 °C), and nuclear survivability [1].

The standard gamma dose rate sensor is the Geiger-Müller tube (or G-M tube). The venerable G-M tube has been the standard dose rate sensor for nearly one hundred years [2]. However, it is expensive for large-scale deployment (an average of $100 per tube), requires high voltage and counting circuitry, and requires several tubes to span the range of dose rates pertinent to military applications. The G-M tube certainly has characteristics beneficial for military applications to include somewhat inherently nuclear survivability, limited temperatures dependence, and very mature technology.

In recent years, a number of radiation manufactures have started to use solid-state devices such a photodiodes for dose rate measurements. These detectors offer advantages in cost, size, and power consumption. However, tests have shown that these types of sensors struggle with nuclear survivable, an absolute must for this type of capability for the military. Temperature sensitivity and non-linearity over a wide dose range also affect many of the current solid-state sensors. DoD is concerned that this evolution of the technology for commercial radiation detectors from G-M tubes to the current solid-state devices continues maybe detrimental to the military’s ability to continue to field radiation detectors that are survivable on the nuclear battlefield.

The DoD has decided to fund research to develop low-cost gamma dose rate sensors that are suitable for military operations, including fighting and surviving on the nuclear battlefield. The successful result of this SBIR topic would be a dose rate sensor that is:

- Low-cost (preferably significantly under $100 per sensor),
- Able to accurately deep absorbed dose rate, defined as the absorbed dose rate at a depth of 10 mm in International Commission on Radiation Units and Measurements (ICRU) tissue,
- Accurate across the dose rate range pertinent for military operations (from background to 100 Gy/hr),
- Able to maintain accuracy over a wide temperature range (-50 °C to 55 °C),
- Nuclear survivable,
- Very rugged, and
- Very attractive to radiation manufactures for use in their radiation detectors for the commercial and medical sector.

PHASE I: Demonstrate through proof-of-concept experiments that the proposed sensor can measure the radiation dose rate, at least in a laboratory environment. Using the results of the proof-of-concept tests, conduct feasibility study to determine if the proposed sensor will meet the overall requirements for DOD and to predict better its expected performance. Plan for the continued development and testing of the proposed sensor. Update the cost estimation for the fielded system based on realistic material costs, testing requirements, and projected DoD needs.
Phase I deliverables will include meetings (at vendor location or telecom) as needed, monthly reports, and a final report with the results from the tasks in the preceding paragraph.

PHASE II: Mature the propose sensor into a prototype system that meets the DoD needs as previously stated. Demonstrate accurate measurement of dose rate throughout the needed range on the prototype systems. Demonstrate and document the prototype sensor’s temperature dependence, nuclear survivable, and ruggedness. Further develop the manufacturing process to ensure quality and reproducibility, while keeping the cost of the final sensor low. Update the cost estimation for the fielded system.

Phase II deliverables will include meetings (at vendor location or telecom) as needed, monthly reports, and a final report with the results from the tasks in the preceding paragraph.

Additionally, the offeror will deliver three of the prototype systems to the government for further testing.

PHASE III DUAL USE APPLICATIONS: Refine and validate the sensor technology to ensure the technology meets the U.S. Army’s concept of operations (CONOPS) and meeting the end-user requirements to include ruggedness and environmental stability. Finalize manufacturing process to ensure a low-cost sensor. Transition the new sensor technology to both commercial and military radiation detectors.

The end-state of the SBIR is a dose rate sensor that is:

- Low-cost (preferably significantly under $100 per sensor),
- Accurate across the dose rate range pertinent for military operations (from background to 100 Gy/hr),
- Able to maintain accuracy over a wide temperature range (-50 C to 55 C),
- Nuclear survivable,
- Very rugged, and
- Very attractive to radiation manufactures for use in their radiation detectors for the commercial and medical sector.

PHASE III DUAL USE APPLICATIONS:
The production quantities of the DoD by itself is not enough to continue to sustain and further mature radiation sensor technologies. Therefore, the proposed sensor must be an attractive alternative for use in commercial radiation detectors. This technology has applications in multiple federal agencies and the private sector for identification of and protection from radiation hazards.

REFERENCES:
1. Using RADFET for the real-time measurement of gamma radiation dose rate Marko S Andjelković, Goran S Ristić and Aleksandar B Jakšić January 2015 • © 2015 IOP Publishing Ltd Measurement Science and Technology, Volume 26, Number 2

KEYWORDS: Radiation, Dose Rate, Nuclear Survivability, Geiger-Müller tube
TITLE: Automated Encounter Documentation and Data Driven Decision Support Systems

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: The objective of this topic is to identify and prototype an algorithm for combat casualty care scene interpretation using sensing modalities such as computer vision with the goal of automating medical treatment documentation and providing inputs on data driven decision support systems aimed at providing diagnosis and treatment recommendations to combat medics during prolonged field care. The algorithm shall be platform agnostic and capable of recognizing interventions performed by the medic to automate patient documentation and allow decision support systems to make inferences regarding the course of treatment. To facilitate immediate access in denied, intermittent, and low-bandwidth (DIL) communications environments, capabilities should be resident on a local device and be able to operate offline. Therefore, the system shall be compatible with current and future program of record systems such as Nett Warrior and Integrated Visual Augmentation System (IVAS). The systems that can ‘perceive’ medic-patient interactions will truly enable autonomous data collection with minimal interaction with the end user. This capability would further support development of robotic autonomous medical systems. The reduction of task and cognitive burden will allow medical personnel to focus on the operational mission to support of Soldier Lethality.

DESCRIPTION: Future combat will likely involve greater dispersion and near isolation over great distances, necessitating units to be more self-sufficient and less dependent on logistical and other support units. The potential for delayed medical evacuations due to anti-access and area denial challenges, poses a difficult dilemma for combat commanders with wounded, sick or otherwise incapacitated personnel and will likely result in periods of prolonged field care (PFC) near the sites of injury pending evacuation windows of opportunity. Such scenarios may require a few organic or attached combat medics to deal with many casualties, minimizing the time spent with each casualty. The DoD and civilian organizations are looking at intelligent systems to provide decision support systems (DSS), closed loop, and autonomous care capabilities to act as PFC force multipliers to enable medics to handle more patients at the same time. However these systems, are heavily data driven. Current data capture systems require hand entry of data which is both time consuming and distracts the medic from providing direct care; while recording patient encounter data (observations, interventions performed, and patient disposition) could wait, treatment cannot. Therefore significant research efforts are underway to provide hands free data entry during PFC. Much of that work is aimed at speech input which itself can distract from direct patient care, is limited to what the medic dictates, and is not conducive to noisy environments. The Army Medical Combat Developer has suggested that medical encounter data be captured by perception systems and interpreted with emerging AI techniques to enable real-time generation of input to on-site medical decision support systems as well as to capture patient encounter data for posting to the soldier’s medical record and forwarding to the next role of care. For such a capability to work, the Automated Encounter Documentation capture would have to be automatic, completely hands free, and capable of working in the dark. Additionally, redundant data storage and analysis on both a local device and in a medical data cloud would be needed to facilitate reliable operation and near-real-time response from DSSs and autonomous care systems during DIL communications, as well as to ensure data would not be lost if the medic’s EUD is lost or destroyed. The use of novel, and multi-modal sensing methodologies is encouraged to automate the capture of a wider range of data elements and to increase data capture accuracy and reliability.

PHASE I: Based on proposed solutions, develop designs to prototype, integrate and demonstrate a proof of concept light-weight perception system that can generate input into mobile medical information systems and decision support systems aimed at providing diagnosis and treatment recommendations to combat medics during prolonged field care or to be stored and potentially forwarded to a government
operated medical data cloud for interpretation and upload to the patient’s medical record. The system shall be demonstrated using representative COTS sensors and hardware with the eventual goal of integrating with a system that can be carried by a single dismounted combatant along with other combat equipment. Identify potential datasets to be used for machine learning strategies. Produce a system design including analyses of alternatives for components to be used for prototyping and demonstration during Phase II. Initiate interoperability and integration plans for future hardware implementations using DoD programs such as the Army’s Integrated Visual Augmentation System (IVAS).

PHASE II: From Phase I work, develop and demonstrate a perception system that can generate input into mobile medical information systems and decision support systems aimed at providing diagnosis and treatment recommendations to combat medics during prolonged field care or to be stored and potentially forwarded to a government operated medical data cloud for interpretation and upload to the patient’s medical record. In order to accommodate initial prototype software evaluations with soldiers in the field and/or for fielding consideration, final system must be capable of being implemented on highly ruggedized, light-weight military End User Device (EUD) hardware. Develop integration plans for DoD programs such as the government owned mobile medical information system. Demonstrate an operational prototype in a field exercise with medics/corpsmen as coordinated by US Army TATRC.

The offeror shall define and document the regulatory strategy and provide a clear plan on how FDA clearance will be obtained. The offeror should plan for Phase III integration of the prototype capabilities with fielded Army or Joint systems. Further develop commercialization plans that were developed in the Phase I proposal for execution during Phase III, which may include exploring commercialization potential with civilian emergency medical service systems development and manufacturing companies. Seek partnerships within government and private industry for transition and commercialization of the production version of the product.

Other important considerations for the system concept include: 1) If a separate battery is used, it should be easy and quick to replace the battery in the field. 2) No new or proprietary display devices should be proposed; if a display is needed for the initial human-in-the loop attended or tele-operated prototyping phases, any required display should be designed to use a standard military issued Android End User Device (EUD) such as the Army Nett Warrior or SOCOM Android Tactical Assault Kit. 3) The system shall be designed with respect to existing and emerging medical device interoperability standards. 4) If intra-device communications are involved in proposed prototype capability, Ultra-Wideband (UWB) communications technology (Ref 15-17) is the desired communications protocol in Phase II for connecting component technologies together and/or to tactical radios for remote teleoperations since UWB is being actively pursued as a secure wireless technology with minimal electronic signature for Open Body Area Networks (OBAN) in combat environments. Use of other innovative solutions for providing secure short-range wireless communications in a tactical environment will also be considered for system designs that require wireless intra-device communications. 5) System should adhere to existing military standards based upon the research approach, such as compliance with existing IVAS standards, if exploring a vision-based perception system. 6) This research is not designed to address the development of wireless capabilities. It is focused on development of a perception system. 7) Speech-to-text capabilities will not be considered. 8) Perception systems include but are not limited to vision-based systems. 9) During Phase II field exercise coordinated by TATRC, the perception system be employed by multiple medics using it in medical scenarios (sample size n=32) to validate accuracy of the perception system. The medical scenarios will consist of medical procedures within a 68W Health Care Specialist’s Scope of Practice, as identified in Soldier Training Publication STP 8-68W13-SM-TG dated 03 May 2013.

The initial demonstration tasks are: 081-833-0065 Apply a Combat Application Tourniquet (C-A-T); 081-833-0068 Bandage an Open Wound; 081-833-0212 Apply a Pressure Dressing to an Open Wound; 081-833-0075 Perform a Needle Chest Decompression; 081-833-0033 Initiate an Intravenous Infusion; 081-833-0168 Insert a Chest Tube; and 081-833-0301 Administer an Intramuscular Injection with notation of

ARMY 91
medication given. 10) This SBIR topic is not to develop new mobile medical applications that are required, but rather a capability that can be integrated into existing mobile military medical applications, such as JOMIS, BATDOK or MEDHUB. The vendor is not responsible for integration into existing mobile military medical applications. Proposals providing an approach, that supports integration that will be performed by or in conjunction with the appropriate government organization in follow-on Phase III spiral development activities, are preferred.

PHASE III DUAL USE APPLICATIONS: Refine and execute the commercialization plan included in the Phase II Proposal. The Phase III plan shall incorporate military service specifications from the U.S. Army, U.S. Air Force, U.S. Navy, and U.S. Marine Corps as they evolve in order to meet their requirements for fielding. Specifications will be provided in Phase II as they become available. The prototype system component may be integrated into a system of systems design and evaluated in an operational field environment such as Marine Corps Limited Objective Experiment (LOE), Army Network Integration Exercise (NIE), etc. depending on operational commitments. Present the product ready capability as a candidate for spiral development fielding (even without completion of the entire system of systems objective), to applicable Department of Defense. Army, Navy/Marine Corps, Air Force, Program Managers for Combat Casualty Care systems along with government and civilian program managers for emergency, remote, and wilderness Medicine within state and civilian health care organizations. Execute further commercialization and manufacturing through collaborative relationships with partners identified in Phase II.

REFERENCES:

KEYWORDS: Perception Systems, Artificial Intelligence, Image Processing, Automated Documentation, Prolonged Care, Electronic Medical Documentation, Electronic Health Record, Medical Robotics, Medical Autonomous Systems, Combat Casualty Care, Autonomous Enroute Care
TITLE: To Develop and Demonstrate an Advanced Combat Wound Care Technology that Prevents Sepsis from Infected Traumatized Tissue

RT&L FOCUS AREA(S): Biotech
TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop and demonstrate a technology that prevents infected and traumatized combat wounds on service members from becoming septic during extended tactical operations in austere environments. The technology shall be in an easy-to-use format, require minimal instrumentation, light weight, and compatible with care under fire (CUF). The method should enable deep tissue penetration of anti-microbial agents, analgesics, hemostatic agents, and pH stabilizers or oxygenating agents in the wound bed at minimum. The technology could be based on but not limited to a gel matrix, a fiber or polymer, a dissolvable gauze, spray and stay chemistry, nano-material, any wave or magnet based technology, or any combination thereof. All novel transformative technologies and ideas not identified here are welcomed. The end goal is to formulate a matrix technology that prevents infection and subsequent sepsis, preserves tissue viability, and promotes healing/regeneration of traumatic wounds in austere environments.

DESCRIPTION: Urban dense terrain and multi-domain operations of the future are expected to generate complex wounds that will require advanced prolonged field care and stabilization when tactical evacuations to robust rear element medical care infrastructures are delayed. Penetrating combat wounds can be accompanied by foreign body inoculum (metal fragments, rocks, dirt), large zones of bone and soft tissue disruption, nerve damage and localized ischemia (tourniquet/edema), as well as severe hemorrhage with resuscitation (often severe, >10U of 1:1:1 – pRBCs, plasma, and platelets that will systemically disturb overall physiology [immune system dysfunction, some degree of traumatic brain injury (TBI)]). Wound infections will be common in the multi-domain battle space and during prolonged field care; these infections could progress to sepsis. According to the Tactical Combat Casualty Care (TCCC) guidelines, the initial response to battlefield trauma is to stop major hemorrhage with pressure, tourniquet and wound packing with hemostatic agents along with broad spectrum battlefield antibiotics. The hemorrhage resuscitation, blast and use of tourniquets significantly reduce the efficacy of antibiotics in combat wound infections and topical treatments are urgently needed. Packing combat wounds with hemostatic agents with evaporative or tissue sealant properties in granular form or impregnated gauze appear to be effective topical treatments to control hemorrhage from these wounds (2,3). However, these approaches are not without their limitations in field applications to include incompatibility with brisk bleeding or coagulopathic patients (4,5) and their unsuitability for long term care (>4 - 5 h). While this paradigm was successful in recent operations where medical evacuation to a higher echelon of care was possible within hours of traumatic injury, the conceivable shift in the future battle space requires serious considerations to this evacuation strategy. As a result, the need for aggressive battlefield trauma care technologies that combine good medicine (i.e. better risk-to-benefit ratio) with host-physiology-augmenting innovations are paramount to controlling life threatening external hemorrhage and sepsis for complex battle wounded service members in austere environments that are removed from access to advanced medical care.

The ultimate goal of the technology in this request is to augment current technologies available in the market in the form of gauze, gels, polymers, or powder that combine hemostatic agents with antimicrobial agents or analgesics alone. Commercialization of a technology that addresses the multidimensional problems of traumatized tissue biology will accelerate the next generation of innovations that combine tissue regeneration, pain management, and immune modulations to prevent sepsis and hemorrhage while expediting wound recovery. The aim of this SBIR/STTR is to develop a universal combat matrix of choice that may deliver multiple components such as but not limited to anti-microbial agents, analgesics, regenerative agents, immune modulators, hemostatic agents, oxygenating agents, and pH stabilizers.
into infected traumatize tissues to prevent sepsis. When proposing a technology, it is paramount, but not limited to, to consider the factors below:

- The starting technology plans to have or already has FDA or equivalent clearance for one or more indications
- The anti-microbial of choice shall cover a wide array of infectious organisms
- The analgesic of choice can be, but not limited to, non-opioid agents
- The regenerative and immune modulators of choice can be, but not limited to, proteins, peptides, hormones, small molecules
- The matrix should stabilize pH and endotherm conditions within the wound bed
- The composition may include, but not limited to, hemostatic agents, metal ions, lantibiotics, natural products, bacteriophages, antibodies, polymers, nano-fibers
- Controlled release of agents as a feature (optional)
- If a wave or magnet based instrument is to accompany a given technology, simplicity of operation and weight will be considered
- Effortless applications, ability to withstand high-winds, water, hot and cold temperatures and minimal storage conditions will be factored in the nomination process

PHASE I: Given the short duration of Phase I and the high order of technology integration required, phase I should focus on system design, compatible composition selection, and development of proof-of-concept prototypes that address the majority of the requirements of interest. Prototypes may combine “classes” of agents into different “sets” of matrices or formulations with sequential application to reflect the different stages and priorities of wound healing. At the end of this phase, working prototypes should demonstrate feasibility and proof-of-concept using in vitro systems for components of proposed technology and establish “release profile”. This phase should identify a pre-clinical animal model of infection, such as, but not limited to, punctured or open soft tissue wounds against a gold standard treatment for Phase II. Proposals may include different formulations for different phases of infection development and healing. Evaluation must include data for the first 24, 48 and 72 hours at a minimum, if not longer.

PHASE II: During this phase, the integrated system should be refined to enhance proof-of-concept into a product. Further optimization of technology for deep penetration of technology components into traumatized wound bed should be demonstrated during this phase. Qualitative and quantitative outcomes of product with regards to wound healing rate, regenerative properties, prevention of infection, pain control, hemorrhage control, and decolonization by invading organisms must be demonstrated as specific performance characteristics of the product compared to commercially available product. This testing should be controlled, rigorous, and under GLP conditions. Testing and evaluation of the prototype to demonstrate operational effectiveness in simulated environments (i.e. extreme heat, cold, wet environment) should be demonstrated. Here, the selected contractor may coordinate with WRAIR to set up testing sites and models. Stability of product in an austere environment should be evaluated to include extreme conditions. This phase should also demonstrate evidence of commercial viability of the product. Accompanying application instructions, simplified procedures and training materials should be drafted in a multimedia format for use and integration of the product into market. The offeror shall define and document the regulatory strategy and provide a clear plan on how FDA clearance will be obtained at the end of this phase. Offeror should also consider a pre-pre-submission communication with the FDA.

PHASE III DUAL USE APPLICATIONS: This phase should encompass both large animal models and randomized clinical trials that would require formal IRB approval as well as shelf-life optimization of at least 2 years in austere environments. The ultimate goal of this phase is to develop and demonstrate a technology enabling the prevention of sepsis in wounded service members from infected traumatic combat wounds and control of hemorrhage under prolonged field care with proper regulatory (FDA) clearance for human use. This effort should seamlessly be integrated into the TCCC paradigm of initial
response to trauma. Once developed and demonstrated, the technology can be used both commercially in civilian or military settings to save lives. The selected contractor shall make this product available to potential military and civilian users. The contractor should coordinate with WRAIR/NMRC to establish a National Stock Number (NSN) as the first step towards the potential inclusion into appropriate "Sets, Kits and Outfits" that are used by deployed medical forces in the Defense Acquisition System.

REFERENCES:

KEYWORDS: wound infections, sepsis, prolonged field care, combat wound care, multi-domain operation, urban dense area warfare
TITLE: Distributed Coded Computing for Content Management at the Tactical Edge

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Electronics

OBJECTIVE: To develop a software solution for edge devices (such as smart phone, robot, UAS, IoT sensors, etc.) to perform distributed computing and content based storage for efficiently processing, storing, and disseminating computational intensive tasks and information across available edge devices in a Disconnected, Intermittent, Low-Bandwidth (DIL) environment. The warfighters will benefit from increased situational awareness under contested environment in support of future Man-Unmanned Teaming operations and IoT sensor applications.

DESCRIPTION: Handheld mobile technology is reaching first responders, disaster-relief workers, and soldiers in the field to aid in various tasks, such as speech, image, video recognition, natural-language processing, command and control, decision making, and mission planning. However, these edge devices offer less computation power than conventional desktop or server computers and the tactical edge networks are bandwidth limited and suffer from intermittent connectivity to higher echelons in contested environment. In addition, exponential growth in mobile sensing technology is generating large amount of content exceeding the ability of individual edge devices to process/store and the network to disseminate them. This requires tactical edge networks to be able to process, store, and distribute content locally using available edge devices.

Distributed computing in the commercial networks is based on centralized schedulers where the scheduler allocates tasks to computing devices and they all report back to the scheduler. Cloud or fog computing in commercial network requires fixed computing infrastructure and 24/7 access to the cloud. Today client server paradigm requires connectivity between edge devices and server hosting platforms. Once the dismounted soldiers get disconnected from the server hosting platforms, there is minimal-to-no capability to process, store, and share locally collected information between connected dismounted soldiers. Separately, in the commercial network, the content based networking approach uses client/server paradigm which is not suitable at the tactical edge. In the academic, there is research being conducted in distributed computing, but mostly following commercial network paradigm.

To address the challenges at tactical edge, an innovative distributed computing approach is required to perform computationally intensive tasks to reduce the collected information into meaningful content using machine learning techniques. The unique aspect of this research involves combining distributed computation with a content based networking paradigm to disseminate and store information efficiently across available edge devices for easy retrieval. Techniques within distributed computing that does not rely on centralized scheduler, works on resource constrained edge devices, addresses changes in number of computing nodes and associated resources and bandwidth limitations is required. New and innovative coded computing paradigms needs to be explored to address challenges of changing computing resources as well as metadata generation, distributed hashing, social networking, and role based encryption techniques to store and disseminate content efficiently across available edge devices should be explored.

PHASE I: Explore and design an architecture for distributed computing suitable for tactical edge network. The architecture shall include machine learning techniques to perform information processing such as object detection, and classification for extracting meaning information. The architecture design shall include content coding and dissemination techniques that considers various network constraints (i.e. computation resources, network bandwidth, and power). The implementation shall include distributed content storage mechanisms, content tagging and encryption technique for secure content dissemination and retrieval. The chosen approach and the algorithms should be substantiated by means of analysis,
modeling and simulation or early breadboard prototyping. This task aims to explore the strengths and weaknesses of the architecture for Phase II.

PHASE II: Implement the above architecture and algorithm on COTS edge computing devices. Develop specification of the protocols which make use of the algorithms from phase I. Software implementation of the proposed protocols and algorithms to be implemented on a COTS platform. Demonstrate the system ability to process information using distributed coded computation and perform object detection, and classification to extract and store meaningful information relevant to the users within the network. Demonstrate and deliver capability in a network consisting of 10 node for laboratory assessment. Deliver a prototype system to CERDEC for further testing.

Demonstrate of capabilities using a network of wireless mobile nodes under a relevant scenario. Demonstration of the scalability properties of the proposed solution using a combination of COTS radio nodes and network emulation tools. Final demonstration shall be conduct in field environment in a network consisting 30 edge computing devices.

PHASE III DUAL USE APPLICATIONS: Development of distributed coded computation along with content based networking techniques can be integrated with Army’s Nett Warrior and Digital Warrior technologies to bring computationally intensive capability that extracts useful information to increase situational awareness capabilities to the foot soldiers on the ground. The proposed software system shall be integrated with hardware and software of Nett Warrior/Digital Warrior. In addition to military applications, this research is applicable for the First Respondent and the Homeland Security environments where distributed computation tasks to be performed are required especially in the events of natural disasters.

REFERENCES:
2. “Mission-Centric Content Sharing Across Heterogeneous Networks” 2019 International Conference on Computing, Networking and Communications (ICNC), Tim Strayer, Ram Ramanathan, Daniel Coffin, Samuel Nelson
3. “Content Sharing with Mobility in an Infrastructure-less Environment” Article in Computer Networks 144 · July 2018, Tim Strayer, Samuel Nelson, Amando Caro, Joud Khoury

KEYWORDS: distributed computing, content based networking, DIL environment, classification, machine learning, cloudlets, fog computing, architecture, edge devices, UAVs, and UGVs
OBJECTIVE: Develop a materiel solution that prototypes a converged network capability designed to converge modern telecommunications and internetworking concepts (e.g. Software Defined Everything (SDx), 5th /6th Generation (5G/6G) cellular) with that of military, tactical radio wireless communications technologies (e.g. Barrage Relay Networks (BRNs), Wideband High Frequency (WBHF) networks, Single Channel Ground Airborne Radio System (SINCGARS), and NATO Narrowband Waveform (NBWF). The target implementation would converge military-specific wireless communications technologies with these modern enabling network technologies. Software Defined Perimeter (SDP) can and should specifically be explored as means to simplify current network designs for military multi-level security services, black/red cryptographic separation and black core networking services. Modern military wireless communications provide advancements, and ready convergence with other advanced wireless communications solutions is critically needed; specifically 5th/6th Generation cellular.

DESCRIPTION: Warfighters need the right information, in the right place, at the right time, wherever they are located. Radio-aware networks are emerging to address these needs. A recent Internet Engineering Task Force (IETF) develop, RFC 8175, defines a Dynamic Link Exchange Protocol (DLEP) mechanism for integrating IP routers and mobile radios, enabling faster convergence, more efficient route selection, and better performance for delay-sensitive traffic – generally known as “Radio Aware Routing” (RAR). The data networking services of SINCGARS, WBHF and the NATO NBWF were developed prior to these innovations. The desired solution at completion will provide the commander the capability to integrate SINCGARS, WBHF and NATO NBWF into converged Internet Protocol (IP) based data networks leveraging modern convergence approaches.

PHASE I: The Phase One deliverable will be a comprehensive white paper describing:
- Study focusing on means to achieve a converged SDx based network leveraging current military tactical radios and 5G/6G cellular technology.
- Analysis of approaches and opportunities for an SDx based tactical network

PHASE II:
- Develop and demonstrate a prototype solution of an SDx- based network leveraging current and emerging PM Tactical Radio platforms and currently available technology (e.g. 5G)
- Phase Two deliverables will include:
  - Prototype solution suitable for supporting a battalion operation which has reached TRL 5
  - Demonstration of the prototype with Army tactical radio systems
  - Test report detailing solution performance
  - Product documentation detailing functions and operations of the prototype Monthly Progress reports. The reports will include all technical challenges, technical risk, and progress against the schedule.
- A baseline schedule for phase III.

PHASE III DUAL USE APPLICATIONS:
- Develop and demonstrate a solution that provides a viable technology insertion to migration to an SDx based design.
- Phase Three deliverables will include:
  - Prototype solution suitable for supporting a battalion operation which has reached TRL 6
  - Demonstration of the prototype with Army owned or emerging radio systems
Test report detailing solution performance
Product documentation detailing functions and operations of the prototype
Productization readiness report which presents any remaining design or implementation issues with respect to suitability to deploy within the command post
Monthly Progress reports. The reports will include all technical challenges, technical risk, and progress against the schedule.

REFERENCES:
2. Wired: “Are you ready for Software Defined Everything (SDx)”, https://www.wired.com/insights/2013/05/are-you-ready-for-software-defined-everything/
4. CSA: https://cloudsecurityalliance.org/working-groups/software-defined-perimeter/#_overview

KEYWORDS: VHF Radio, HF Radio, Digital RF, Signal Processing, HMS, SINCgars
A20-140    TITLE: High Performance Optical Fibers for 100-Watts Infrared Lasers

RT&L FOCUS AREA(S): Directed Energy
TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop a high performance, low loss (less than 0.5dB/m), infrared (IR) fiber technology for transmitting high power (greater than 100 Watts CW) from a multi-band mid-infrared laser (2-6 micron).

DESCRIPTION: Infrared (IR) lasers are of high importance to the US military for multiple applications including infrared countermeasures (IRCM), free space optical communications, and imaging laser radars. To provide increased capability in these areas, the Department of Defense has made significant investment in high power IR laser sources. The objective of this SBIR is to leverage the advancing laser technology for IRCM systems by developing a corresponding high-performance infrared fiber technology.

Current IRCM laser systems integrate a multi-band mid-infrared laser with a pointer-tracker as a mated pair, comprising a single replaceable unit. The pointer-tracker assembly then directs the laser power to confuse and jam the attacking threat missile. Performance and reliability of current IRCM laser systems in high-power, high-stress environments is limited by thermal and vibration issues due to the use of free-space optics in the laser systems. The potential use of optical fiber to transmit the high-power laser beam to the pointer would create IRCM systems that meet the requirements of Modular Open Systems Approach (MOSA), whereby the infrared lasers and pointer-trackers become line replaceable units (LRU) connected through fibers. This would enable IRCM laser systems with simpler vibration isolation, better thermal control, higher performance and reliability, and significant cost reduction (unit, repair, and maintenance costs). Fibers with appropriate composition should be robust and reliable so that they can be made insensitive to temperature changes, vibration, and moisture. Fiber strength and resistance to mechanical damage are also important.

Current fiber capabilities at these wavelengths are limited by either water absorption or other losses. In addition, fiber strength and ability to withstand adverse environments is an issue. New technology is required to advance the state of the art in mid-infrared fibers to fulfill emerging requirements. Of particular interest would be methods for providing advanced infrared transmissive materials with high performance characteristics. The ability of the material to withstand representative stresses and survive in the extreme environments found in Army applications is also of interest.

The development, characterization and demonstration of fiber production, infrared transmission and advantageous material properties of fibers are key elements of any proposed research. The ability to integrate these fibers with traditional fiber components, such as connectors, multiplexers, other fibers and switches, would be advantageous. Efforts are needed to develop novel approaches to achieving development of these high performance fibers and maturation of the technology and manufacturing base. The end result of this research would be high performance optical fibers to advance the state of the art in mid-infrared laser applications.

PHASE I: Design an approach to produce optical fibers capable of low-loss (less than 0.5dB/m) transmission between 2-6 micron that exceeds the current state of the art. The optical fiber must have the capacity of transmission greater than 100 Watts laser power over 5-meter long fiber with the mechanical properties to operate in military environments (vibration, temperature, and humidity). Demonstration and measurement of physical properties such as fiber strength and resistance to the environment is critical. Since there is more than one wavelength to be covered, the fiber should be able to transmit a broad range of wavelengths (2-6 micron). A clear development path toward manufacturing the new fiber technology...
must be presented. The Phase I deliverable will be a final report including the initial fiber technology and performance assessment.

PHASE II: Demonstrate production of usable lengths of mid-infrared fiber to transmit high power (> 100 Watts CW) laser output in the 2-6 micron region with less than 0.5dB/m loss and high material strength. The minimum requirement for the constructed and demonstrated fiber prototype is 25W of optical power transmission with low-loss (<0.5dB/m). The transmitted beam shape should be as close as possible to a smooth Gaussian beam, which would typically be launched into it. Survivability of fibers under representative stress (such as applicable Mil-Specs) should be demonstrated. Key factors for this fiber technology are reliability, reproducibility, cost, and transmission characteristics. Required Phase II deliverables will include a fiber prototype, tests in a laboratory environment, and a final report.

PHASE III DUAL USE APPLICATIONS: Military. Upon successful completion, set up a manufacturing process to produce high performance IR fiber that will transition to the Army and DoD for integration into IRCM defensive systems being developed for rotary and fixed wing aircraft.

Commercial. High performance optical fibers for high power IR lasers should find uses in laser marking, laser machining, and laser micromachining. The new fiber technology in the IR wavelengths has potential applications in medical laser procedures, remote bio/chemical detection, and scientific instruments. Mid-wave infrared (MWIR) radiation is a valuable tool for spectroscopic investigations, and the use of fiber-optic technology in this wavelength band allows spectroscopic measurements to be made in normally inaccessible locations.

REFERENCES:
1. F. Chenard, et al., "MIR chalcogenide fiber and devices", Proc. SPIE 9317, Optical Fibers and Sensors for Medical Diagnostics and Treatment Applications XV, 93170B (5 March 2015); https://doi.org/10.1117/12.2085056.

KEYWORDS: IRCM, fiber optics, single mode, Chalcogenide, low-loss, laser beam delivery, cable
TITLE: C4ISR/EW Modular Open Suite of Standards (CMOSS)-based Common Data Link (CDL) Radio Transceiver

RT&L FOCUS AREA(S): Network
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Design and build a C4ISR/EW Modular Open Suite of Standards (CMOSS)-based Common Data Link (CDL) Radio Transceiver.

DESCRIPTION: Increases in Operational Tempo (OPTEMPO) and the need for greater mobility to support operations On The Move (OTM) are driving requirements for reduction in Size, Weight, and Power (SWaP) for U.S. Army intelligence ground stations. CMOSS-compliant OpenVPX chassis and modules are the target form factor for USARMY tactical communications electronics. This includes sensor radio transceivers. CDL is a secure U.S. military communications protocol that is the primary protocol for communicating with imagery and signals intelligence sensors. This includes aerial sensor platforms such as Joint Stars, EMARSS, and ARL-E. The current effort would port a successful proven technology (CDL) to an innovative platform. Developing a CMOSS-based CDL radio transceiver would increase modularity and maintainability/usability in the ground stations, as well as reducing SWaP.

PHASE I: Develop overall system design that includes specification of module component design, interfaces, CMOSS module profiles, and required CMOSS chassis profiles.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct field testing to prove feasibility in connecting to CDL sensor platforms.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of USARMY and USAIRFORCE ground stations, including the USARMY Tactical Intelligence Targeting Access Node (TITAN), connecting to space (Commercial and Military), aerial (Joint Stars, EMARSS, and ARL-E), and terrestrial sensor systems (TLS, Prophet).

REFERENCES:
1. SOSA Snapshot 1 FEB 18 (CMOSS Profiles)
2. CMOSS Profiles in OpenVPX JUL 17
3. VITA 46.0 VPX
4. VITA 46.1 VPX
5. MORA Requirements in ANSI/VITA 49.2 JUL 17

KEYWORDS: CMOSS, sensors, CDL
TITLE: Federated Intelligence, Surveillance, Reconnaissance (ISR) Collection Management Using Machine Learning (ML)

RT&L FOCUS AREA(S): Network, AI/ML
TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The desired end product of Phase II is to have a federated collection management software that provides a coordinated collection plans across National to Tactical ISR collection to include Joint and Mission Partner Environments (MPE) using machine learning to optimize collection plans across the enterprise.

DESCRIPTION: The Army technical problem can be broken down into several areas as it relates to Multi-Domain Operations (MDO). First, current collection plan generation is performed in a silo approach based on mission objectives. Often times it is completed through spreadsheets and PowerPoint. Second, these collection plans are not visible or sharable to entities outside of unit organizations that create them. Third, this leads to redundant collection plans often times relying on ISR collection assets that would be collecting on plans that may have common objectives. This leads to inefficiencies and increased timeliness of critical information. Lastly, collection plans are largely manually generated which requires multiple human generated steps to develop an optimized collection plan that has no relationship to other collection plans that may have similar objectives or National/Tactical ISR collection assets could collect in route if multiple desperate collection plans are geo-spatially and temporally close.

PHASE I: Provide a concept that addresses the challenges related to objectives of this SBIR. As part of the concept define what the minimum viability of the capability will provide with the goal of increased functionality while providing a fluid user experience in Phase II. Phase I shall also address concepts for built in training and reminders for users to quickly operate and maintain proficiency of the system.

PHASE II: Provide a physical proof of concept system that showcases how a federated collection plan is implemented with some level of automation applied in the creation of collection plans. Additionally, the proof of concept system shall implement machine learning to optimize the federated collection plans while also enabling unit organizations to significantly improve their abilities to leverage existing or previously generated collection plans that potentially have similar objectives.

PHASE III DUAL USE APPLICATIONS: This SBIR would enable current Synchronized High Op-tempo Targeting (SHOT) S&T efforts that are part of the Long Range Precision Fires (LRPF) portfolio. SHOT does not currently have a federated ISR collection task. The SBIR would also enable the Tactical Intelligence Targeting Access Node (TITAN) program under PM DCGS-A which would provide a path for transition into an operational capability. Lastly, the commercial applicability of this effort shall support commercial geospatial capability providers as well as consumers that utilize commercial satellites, manned/unmanned aircraft for land/surface surveilling to include law enforcement.
REFERENCES:

KEYWORDS: ISR, MDO, MPE, National, Tactical, Collection Plans, Collection Management, SHOT, LRPF, Machine Learning, TITAN
TITLE: A Novel Non-Uniformity Correction (NUC) Approach for Night Vision Cameras

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The objective of this project is to develop a novel technique to perform Non-Uniformity Corrections (NUC) of infrared focal plane arrays by minimizing and potentially eliminating the need to use active thermal reference sources. The desired approach is to use an in Dewar variable aperture or other similar mechanism to generate the gain and offset parameters in place of active thermal reference sources and thereby eliminate the resultant loss of live infrared imagery to correct staring arrays. The results of this project will be used by the Government to assess the feasibility to eliminate the cost of the active thermal reference sources and reduce the time required to perform the NUC.

DESCRIPTION: Sensors using cooled staring focal plane detector arrays will typically need some form of NUC to suppress random noise such that the scene can be viewed accurately. The pixel-to-pixel variations are typically characterized as differences in gain and offset. The gain parameter refers to the slope of the pixel output (rate of change) response versus the input signal and the offset parameter is a fixed additive value unique to that specific pixel. The non-uniformity issue arises when each neighboring pixel in the focal plane array has a different gain and offset which leads to a fixed pattern noise which can dominate the output video unless it is electronically compensated. A standard method of compensation involves blocking the focal plane array with a known uniform source at different temperatures to measure each pixel’s gain and offset values and then apply these offsets to each pixel on live output video to remove the fixed pattern noise. The downside of this approach is that while the thermal reference source is being used for a NUC the focal plane array is blocked from viewing the outside scene and thereby blinding the operator.

The 3GEN FLIR is a new technology for combat vehicles that incorporates a variable aperture mechanism (VAM) inside the cold space of the Dewar to vary the F# to enable the sensor to switch long focal length optics without increasing the aperture size. The aperture mechanism is structured like a conventional iris such as used in photographic camera optics. This means that the change in aperture shape will vary the amount of light flux from a given object source in a controlled and known fashion. By including the VAM in the NUC process to change the incoming photon flux instead of the thermal reference source, the NUC could be performed faster and not block the live image from the sensor operator. This new technique could be applied to a full two point correction calibration at system turn on and one point offset correction during live scene viewing thus eliminating blackout time of the sensor. This Novel NUC approach would eliminate blind time, which is extremely important to the warfighter that is common with the conventional NUC approach that uses thermal reference sources.

PHASE I: Develop the non-uniformity process sequences, algorithm, and performance metrics for one and two point simulated corrections using an in Dewar variable aperture mechanism or similar mechanism in the optical chain without the presence of an active thermal reference source compared to
the conventional approach with a thermal reference source. Use Mat Lab or equivalent software to show with at least static imagery that the variable F# technique (either in Dewar or in the warm space) can correct the spatial noise of a longwave focal plane array to less than 25% of the temporal noise. Also, demonstrate the compatibility of the process algorithm with other scene-base non-uniformity correction methods that may be running in parallel. Deliver documentation of the work effort and the results in a technical report per DI-MISC-80048.

PHASE II: Using a 3GEN Dewar (this will be a GFE), produce a breadboard apparatus and perform laboratory and field tests in both static and on the move scenarios with live video-rate processing to obtain non-uniformity corrections that result in the spatial noise to be less than 25% of temporal noise. Measure performance over an eight hour window and check the stability of the corrections. Document and deliver the optimum processing algorithm, actual test apparatus hardware details, and the test raw data, analysis, and conclusions per DI-NDTI-80809B.

PHASE III DUAL USE APPLICATIONS: The end state is the 3GEN FLIR which will eliminate the Thermal Reference Source and use the variable aperture for the non-uniformity correction. The transition will be Low Rate Initial Production (LRIP) and full rate Production of the 3GEN FLIR through an engineering change proposal. Having Non-uniformity correction capability that doesn’t block the visual scene can be applied across DOD and industry for Night Vision Devices.

REFERENCES:
5. Computational Sensors Corp “CSC-341-IR ROIC with analog Domain Bad Pixel and Nonuniformity Correction.”

KEYWORDS: Variable Aperture Mechanism, 3GEN FLIR, Non uniformity correction, infrared, offset, gain, focal plane array
TITLE: Aerostat Payload Protection (APP) System

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Materials

OBJECTIVE: The objective of the Aerostat Payload Protection (APP) system is to minimize Aerostat payload damage when Aerostat flight operations are terminated and the Aerostat descends back to the ground.

DESCRIPTION: Modern Aerostats carry very sophisticated and expensive Electro-Optic/Infrared cameras, RADAR, and Communications payloads. These Aerostats also possess a Flight Termination System (FTS) that quickly bring the Aerostat to the ground in the event of major events such as a fully severed tether, or deliberate user initiation.

Currently, when the FTS is activated, these payloads frequently impact the ground at high velocities. The payloads are often damaged to the point that they become partially or fully Non-Mission Capable (NMC). Mission losses are approximately $10 million per year (approximately $1,000,000 of payload lost in 10 incidents per year).

The typical damage modes of these payloads include:

- Impacting the ground with relatively high impact velocities in a direction normal to the ground (i.e. high kinetic energy)
- Impacting the ground with a relatively high deceleration rate (i.e. high “g-loading”)
- Impacting the ground with a relatively high velocity parallel to the ground (i.e. “scraping”)

The APP will be a feature or system on, in, or of the Aerostat, to significantly reduce the level of payload damage and incurred costs.

PHASE I: Generate an APP design concept with a technical feasibility that would lead to an eventual (at Phases 2 and 3) physical manifestation. Multiple (three) concepts are recommended to perform trade-off studies for performance, reliability, and SWAP-C comparisons of the different design concepts. Describe the CONOPS (Concept of Operations) of the design(s). Perform basic, essential Engineering studies that would demonstrate the efficacy of the design (“hand calculations”, MS-Excel worksheets, etc.). Perform simulations or computer modelling (kinematics, kinetics, FEA, CFD, etc.). The main goal of these calculations is to predict the performance of an Aerostat with an APP before it is ever built. For any computations involving actual numbers, sample data can be provided for Aerostats in the 22 to 36 meter range. Some the parameters for these computations will include:

- Weight of the Aerostat (W_aerostat)
- Lifting capability of Aerostat (L_aerostat)
- Weight of the Payload (W_payload)
- Weight addition as the result of incorporating an APP system (W_app)
- Altitude of Aerostat when activating the APP (z_act)
- Prevailing wind velocity at time of APP deployment (v_wind)
- Distance from mooring platform (r_MP)

To better illustrate the APP objective, several examples of design concepts are presented below. These are for guidance only, and not direction. Furthermore, these in no way shall limit, constrain, or otherwise drive the solution:
• Controlled release of Helium to ensure that the Aerostat both touches down at a slow enough velocity but also does not migrate beyond a required distance from the Mooring Platform (i.e. “throttling” of the release valves, using on board GPS and altitude sensors, etc.)
• Parachutes, including steerable versions
• Inflatable cushions (aka “airbags”)

And here is a sample CONOPS:

“The Aerostat’s APP system, as the result of an adverse incident or by user input, is triggered. The APP automatically executes an action or sequence of actions which will bring the Aerostat from its initial operating altitude down to ground level, within a defined distance from the Mooring Platform. At the moment that the payloads hit the ground, they have either impacted the ground at a sufficiently low velocity, or have a sufficient deceleration zone so that the g-loading is low and payload damage is minimized. The payloads can be subsequently recovered with a minimum of inspection or repair, re-installed on a new Aerostat, and re-launched to altitude.”

As Aerostats are exceedingly weight sensitive airborne vehicles, the total added weight from incorporating an APP shall be less than 10% of the Aerostat’s payload lifting capability. As an example, a typical 36 meter long Aerostat has a payload lifting capability of approximately 1,000 lb.

PHASE II: The Phase II effort would equip and demonstrate a functional APP system on an Aerostat with a minimum 12 m overall length.

The following will be some basic functional requirements:

• The APP shall be capable of activation both automatically (due to separation of the tether-to-ground connection), or manually from the ground based on user input.
• The APP shall ensure that the designated payloads retain Full Mission Capability (FMC) after the APP is activated at an altitude of z_act and the payloads return to an altitude of z = 0 while prevailing winds are at a velocity from 0 to v_wind. For reference, the typical payloads would retain FMC after being subjected to MIL-STD-810 Method 516.8, Procedures IV Transit Drop, VI Bench Handling, and VIII Arrested Landing.
• The payloads shall return to the ground within r_MP of the Mooring Platform, in the prevailing winds with a velocity v_wind.
• Weight of any new APP components shall be less than W_APP.
• The APP shall be capable of protecting payloads up to W_payload.

Where mathematical symbols are presented above, the actual values that will be assigned to those symbols will be provided based on the outputs from Phase I.

PHASE III DUAL USE APPLICATIONS: The goal of Phase III is a fully operational Aerostat equipped with a functional APP system. A full size, 1:1 prototype of the APP shall be constructed and tested. This will be for an Aerostat of approximately 28 m to 36 m overall Aerostat length. PD Aerostats will provide the basic Aerostats, dummy payloads, and the test site for demonstrating APP trials. Values for requirements will be provided at this phase.

The commercialization potential for this APP would include military and civilian Aerostats (i.e. tethered balloons and even unmanned airships).

An approximate cost for estimate for the APP implementation will be an output from Phase III.
REFERENCES:
1. www.rc-zeppelin.com
2. www.tcomlp.com

KEYWORDS: Aerostats, airships, survivability, parachutes, inflatable restraints, airbags, controlled descent, impact, shock mitigation
TITLE: Active Noise Reduction HGU-56P Aviator Helmet

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Reduce noise and improve speech intelligibility with least weight increase to HGU-56P Aviator Helmet

DESCRIPTION: Improved speech intelligibility is a fundamental component of soldier lethality, one of the six army modernization priorities of the Army which includes the core requirement of communication. Army aviation has relied on noise cancelling microphone technology based on performance specification MIL-PRF-26542F for over 20 years. Naval aviators have relied on active noise reduction (ANR) earcups with the same microphone based on performance specification MIL-E-29581 for over 20 years. The Army never adopted the ANR system because the Navy specification calls out Rigid Earcups (paragraph 3.3.2.1.1) which violates the requirement for impact protection in the ear dome to prevent basilar skull fractures. The ANR earcup was considered too heavy and rigid for integration into the HGU-56P.

Active noise reduction technology has improved and the electronics for achieving better speech intelligibility has shrunk dramatically since the original Navy specification was released. Commercial headsets commonly used on jets and rotary wing aircraft which incorporate ANR include the Lightspeed Zulu 3 Aviation Headset - GA Plugs: https://www.lightspeedaviation.com/product/zulu-3-anr-headset; Bose A20 Aviation Headset: https://www.bose.com/en_us/products/headphones/aviation_headsets/a20-aviation-headset.html; David Clark DC PRO-X2: https://store.davidclark.com/dc-pro-x2-series

Improvements among these and other headsets designed to address better passive and active noise reduction include better ear cups which allow sealing the ears even when wearing eyeglasses, lighter weight, reduced size, improved active noise cancellation, automatic gain control, and active equalization. In addition, modern aviation headsets include either a standard interface audio jack or Bluetooth allowing commercial phones to be used while in flight without taking off the headset, something else not core but desired.

This solicitation intends to identify an existing commercial solution to provide the best overall reduction in ambient noise reaching the user’s ears while improving speech intelligibility. Threshold improvement requirement is 10% over current sound attenuation of the HGU-56P Aviator helmet. Objective is 30 decibels of noise reduction average across frequencies without removing speech from user as side effect.

According to the Department of Veterans Affairs, hearing problems such as tinnitus are described by the VA as among “the most prevalent service-connected disability among American Veterans.” Improved hearing protection can not only improve communication, it can reduce hearing loss and the cost of long term veterans benefits paid to our service members.

PHASE I: This effort shall identify and test the most promising combination of passive and active noise reduction technology that can be retrofit into the HGU-56P aviator helmet at the least weight and cost. The initial proposal shall identify a solution which provides noise reduction data showing acoustic attenuation of the technology proposed by comparison to paragraph 3.4 of MIL-E-29581 earcup and MIL-PRF-26542F microphone (if proposal includes replacement of microphone). The contractor shall perform a laboratory demonstration in Phase I demonstrating and quantifying noise reduction and speech intelligibility improvement in benchtop tests using two Government furnished HGU-56P helmets. The contractor shall modify one of the helmets with the proposed improvements and perform identical tests using one modified and one unmodified HGU-56P helmet so that comparison data clearly shows
performance improvements achieved. Noise reduction shall be measured using a probe microphone method (REAT Method is not allowed). A report shall be provided which details the tests performed and the improvement demonstrated. Speech intelligibility shall be evaluated using the Modified Rhyme Test method (ANSI S3.2-1989). A Noise Reduction Rating shall be produced IAW ANSI S3.19-1974. The contractor shall document changes to the existing earcup and/or microphone specifications which definitize performance improvement. The report shall estimate costs and weight impact of the technology solution proposed. Measurement of real-ear attenuation of hearing protectors shall be performed IAW ANSI S12.6. The current sound attenuation of the HGU-56P aviator helmet when tested IAW ANSI S12.6 is as follows:

- Frequency (Hz) 125 250 500 1000 2000 3150 4000 6300 8000
- Attenuation (Decibels) 17 14 20 21 26 38 37 44 42

PHASE II: The solution identified in phase I will be applied and tested to meet all requirements of the specifications proposed for update or replacement. As example, if a replacement earcup is proposed, the existing earcup specification (MIL-E-29581) would serve as a starting point for a new earcup specification. Likewise, if the microphone is proposed to be replaced, the microphone specification (MIL-PRF-26542F) would serve as a starting point for a new microphone specification. The contractor shall propose written changes for any existing hardware specifications associated with hardware being changed or replaced. All testing shall be performed IAW the updated hardware specifications submitted by the contractor. A summary report at the end of the test shall document all performance improvement of the new solution to include capabilities added to the performance specifications identified in Phase I. If testing shows initial projections of performance differ from actual results, the contractor shall update any product specifications being replaced or updated as necessary. The contractor shall perform bench testing for all earcup specification requirements on production representative prototypes if the earcup is being modified/replaced with an earcup equipped with ANR IAW a contractor proposed update or replacement of MIL-E-29581. The contractor shall perform bench testing for all microphone specification requirements on production representative prototypes if the microphone is being modified/replaced with an improved noise cancelling microphone IAW a contractor proposed update or replacement of MIL-PRF-26542. The contractor shall build sufficient quantities of noise reduction solutions and retrofit Government furnished HGU-56P helmets to account for testing all performance requirements in the updated specifications. The new noise reduction system shall be capable of being retrofit into the HGU-56P helmet without special tools. Objective of the replacement solution is to be capable of installation as direct part swap for original component(s). The ANR solution shall be capable of accepting power between 3 and 5V DC for operation.

Deliverables will include test plan, test report, updated performance specification(s) reflecting measured improvement in audio performance, minutes for all meetings conducted with the vendor, presentation slides for test readiness review, a white paper detailing the installation cost of the retrofit solution, and a cost report detailing manufacturing cost as a function of helmet quantity from a minimum of 50 and up to 1000 at a time.

TRL: (Technology Readiness Level) TRL Explanation Biomedical TRL Explanation TRL 6 - System/subsystem model or prototype demonstration in a relevant environment

PHASE III DUAL USE APPLICATIONS: Develop production processes and implement any design changes required to optimize components for retrofit into HGU-56P helmet. Update any specifications needed to reflect final production configuration weight and performance. Repeat bench qualification testing if production configuration deviates too far from prototype configuration tested in Phase II. Support operational testing on multiple Army rotary wing aircraft. Aviation helmets used throughout DOD may find retrofit application for this same solution. Most aviation headsets are designed for fixed
wing applications (quiet cockpits) due to their greater density in commercial applications (moving people and cargo). This solution will be optimized for rotary wing applications which are far louder, and will therefore have commercial applications in both commercial helicopters, service and maintenance activities around operational aircraft on runways, motorcycles, and the racing industry where engine noise is very loud.

REFERENCES:
2. https://jramc.bmj.com/content/141/2/98

KEYWORDS: Active Noise Reduction, Acoustic Noise Reduction, Passive Noise Reduction, Speech Intelligibility
TITLE: Low Voltage Cable Reflectometer Built in Test Module

RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop a modular circuit board which implements a low voltage reflectometer capable of determining cable faults and reporting results back to a processor or Field Programmable Gate Array (FPGA) as part of Built in Test (BIT) circuitry. Goal is to demonstrate a cable test technology for integration at the circuit board level for new electronics equipped with data, power, and antenna cables that are human, aircraft or vehicle mounted (not long distance transmission).

DESCRIPTION: Improved and simplified troubleshooting of electrical systems constitutes a fundamental component of sustainment, which falls under soldier lethality, one of the six army modernization priorities of the Army. PM Air Warrior is developing the next generation of body mounted electronics for the aviator. Previous development efforts ran into substantial reliability issues with body mounted cables due to their tendency to flex and crimp far more than what is seen on an air or ground vehicle. Cable and connector issues were a big contributor towards an unsuccessful conclusion of that program. The Rapid Innovation Fund topic “Wireless Air Soldier Power” is developing a power and data hub through which all body mounted cables will be connected. While digital BIT is implemented, analog wire testing is not part of the current design approach.

The Office of the Secretary of Defense (OSD) recently polled the development program managers Army wide for feedback on the deployment and use of test equipment designed to identify intermittent faults in electronics. Due to the weight and cost of external support equipment capable of this, plus the training associated with adjusting the results for the equipment under test, an external test set is not desired. Instead, an internal test which allows the user to know if the system has problems prior to mission start is needed providing immediate go/no-go status of cabling which includes assessment of whether wire performance is likely to experience intermittent failures if signals show weak spots.

While cable test reflectometers have been around for many years, methods that work with much lower voltage have recently been developed that can test external cables from a central box using an approach integrated inside the box. Research on this includes the following citations:

- https://pdfs.semanticscholar.org/7903/3efd09b2a44016c5896442a6c13b57586dc5.pdf
- www.emo.org.tr/ekler/b849cf30f2a2030_ek.pdf
- https://www.researchgate.net/publication/228888052_INTELLIGENT_FAULT_LOCATION_FOR_LOW_VOLTAGE_DISTRIBUTION_NETWORKS

This solicitation intends to identify existing low voltage cable assessment test equipment and incorporate this technology into a modular chip capable of introduction to a circuit board with the following features identified:

- Recommend interface for standardized chip to communicate with processor or FPGA.
- Cable types that can be evaluated (single strand, twisted pair, coax, Twinax, etc.)
- Upon verification of working system operation after initial installation, perform a baseline assessment of existing cable performance.
- Upon startup BIT for all subsequent power on to system, perform assessment of existing cables and compare to assessment of initial verified operational cables. If significant deviations found, provide code to processor or FPGA corresponding to which connector and pin is found to be a potential problem.
PHASE I: This effort shall develop and demonstrate a breadboard prototype circuit board capable of identifying fault types of different cables connected to the circuit board to include short circuits, open circuits, and intermittent faults due to loose or damaged pins in connectors. A laboratory demonstration is required to demonstrate breadboard operation of the circuit board and show proper fault analysis when faults are introduced. A test plan is required showing how faults will be introduced to the cables and what faults can be detected by the tester. A test report is required documenting the results of the laboratory demonstration and the accuracy of the fault detection actually achieved by the circuit board. The contractor shall write and deliver a plan for a Phase II integration of the circuit board into the power and data hub. The integration plan shall project cost, size, weight, and power consumption of the circuit board to be integrated into the power and data hub based on the breadboard build prototype.

PHASE II: The contractor shall partner with the vendor building the power and data hub to design a modification introducing a circuit board prototype to deliver a new power and data hub that can automatically detect cable faults as part of the power up sequence for BIT, and allows a “calibration” function that the user can implement when a working set of cables and subcomponents are mated to the hub. A total of not less than eight hubs with the fault detection chips introduced shall be built and delivered. An interface control document shall be provided to the Government and the hub vendor detailing mechanical and electrical interface for the fault detection module. The HUB vendor shall have project management control of weight/space/power assignment of the fault detection module integration.

The contractor shall host a Preliminary Design Review and perform a Critical Design Review (CDR) at the Government’s facility in month eleven. Critical Design Review (CDR) shall serve as the first milestone at the end of year one. Both design reviews shall make projections for weight/space/power requirements of the fault detection module. CDR shall present a cost projection for the fault detection module. Design reviews shall address how the fault detection module will have access to all hub connector wires without interference in normal operation, automatic activation when BIT is initiated, automatic disable of module operation when BIT is not active, how faults will be reported to hub processor, and an assessment of fault determination and accuracy. Delivery of fault detection modules to the HUB vendor for integration shall serve as the 2nd year milestone.

The contractor shall provide technical support to the HUB vendor by phone and travel to the hub vendor site for first integration build activity. The contractor shall design the fault detection module as a circuit board module within the hub. The contractor shall provide final measured fault detection module capability and weight/space/power information to the hub vendor so that the product specification for the hub can be updated. The contractor shall perform a bench demonstration of the first fault detection module built to verify space/weight/power, functions, and capability.

Deliverables will include briefing slides for the design review, meeting minutes for bi-weekly status telecons and design reviews, a test plan for fault detection module performance demonstration showing compliance to hub integration requirements, test report documenting test accomplishments, data for updated hub performance specification reflecting measured fault detection module performance, and a report detailing projected cost of the final fault detection module design as a function of quantity from a minimum of 50 and up to 1000 at a time. A preliminary technical data package for the fault detection module shall be delivered.

PHASE III DUAL USE APPLICATIONS: Develop production processes for fault detection module prototypes built and delivered in Phase II. Update the hub item specification to reflect final production process weight and performance impact based on production configuration fault detection module. Build thirty six (36) production representative fault detection modules to supply to hub vendor for final operational testing on multiple US Army helicopter configurations. Provide technical data package for fault detection module. Fault detection module may migrate into other Army avionic boxes under
development. Primary commercial application of fault detection module may focus on vehicle wire harness interface to central computers, dedicated controllers for industrial machines with complex wire harnesses, and network hubs delivering Power Over Ethernet (POE).

REFERENCES:
1. Sensors & Transducers, Vol. 183, Issue 12, December 2014, pp. 8-12, Reflectometer for Cable Fault Location with Multiple Pulse Reflection Method
2. Ho C. M., Lee W. K., Hung Y. S., Signature representation of underground cables and its applications to cable fault diagnosis, in Proceedings of the 2nd International Conference on Advances in Power System Control, Operation and Management (APSCOM’93), 7-10 December 1993, pp. 861-865

KEYWORDS: Intermittent Cable Fault Detection, time domain reflectometer
TITLE: Light-weight Internal-combustion High-power, Transformative, Novel, Individual New Generator (LIGHTNING)

RT&L FOCUS AREA(S): general warfighting, network
TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Design, develop and demonstrate a light-weight, Soldier wearable, safe, small Soldier Power Generator (SPG) system using JP-8 fuel as a minimum.

DESCRIPTION: The Soldier’s power generation capability must provide an on-the-move power to enable battery recharging. System weight including 350 Watt-Hours of fuel (inclusive refillable Bladder / canister type fuel container) shall be less than 3 Lbs. A minimum of 30 Watts continuous power shall be provided with ability to have a “LOW” setting at 20W, a “MEDIUM” setting at half way between 20 W and Maximum, and a “HIGH” setting at maximum power to allow the operator to adjust power available, noise, and fuel conservation as needed. The LIGHTNING system shall have an attachable hose (not included in system weight) to allow for indoors operation or to vent heat exhaust away from the Soldier. Fuel at a minimum will be JP-8, with objective of being multi-fuel system. The LIGHTNING System shall have a volume of less than 60 cubic inches including fuel and with a length and width not exceeding 7 inches and a depth not to exceed 3 inches in any dimension, with an objective of less than 45 cubic inches. System design and implementation shall allow for Soldier operation between -20°C to +55°C, be rugged, droppable, operate in rain and immerse able (2 hours 1 meter – shake out and able to be restarted without system damage) in Soldier use environments (iaw MIL-STD-810). The system shall have an embedded self-start function that may use power from the Soldier’s 10 to 20 VDC battery. A selector switch shall be provided to select between 10 to 20 VDC output (15-19 VDC Nominal) and 10 to 32 VDC output (28-32 VDC Nominal) power output. Full power shall be available within 5 seconds. Output power shall be interoperable with items that can scavenge power looking for Maximum Power Point Tracking (MPPT) when connected to external systems (Examples – Thales Universal Battery Charger – Lite; Revision Squad Power Manager (solar panel input); Advanced Power Electronics Corporation – Solar In-line Recharge Enabler). The system shall be relatively quiet generator < 80 dB (Threshold) / < 60 dB (Objective) at 30W output. The system shall be safe to touch (iaw MIL-STD-1472) (T); <3°C higher than ambient Temperature (O). The system shall provide Safe on-Soldier and on ground operations (T) and operate indoors (may include snorkel to outdoors) (O). The system shall be designed to operate for 2000 hours operation with minimal maintenance. At a minimum, the LIGHTNING System shall have a two pin shrouded trailer hitch and / or a 7 socket GlenAir Mighty Mouse (i.e. Glenair Part Number 8071-1472-12 / 8070-1299ZNU7-7DY - 807-663-12/807-348-01ZNU6-7SY, 8070-1675-01ZNU6-7SY or equivalent connector). The system shall be safe with minimal carbon monoxide output. Future objectives would be to output power such that it is compliant with System Management Bus (SMBus) version 1.1 or higher output to directly charge batteries as one of its output power modes, and to provide power that has an auto shut off function when the power drain is minimal. Other objectives would be to have items such as a digital readout with power out, time remaining on current cartridge/canister/bladder of fuel, and system state of health (SOH) / overall hours operated, if SMBus controlled output, - connected battery State of Charge / SOH, and time to charge complete, etc.

PHASE I: Develop an innovative approach and a detailed design of the proposed LIGHTNING System that would employ JP-8 fuel source. The design shall take into consideration the Soldier’s equipment and space claim along with appropriate placement on the Soldier, its human factors to include comfort, acoustics, emissions, etc., in order to provide a positive implementation for use on the Soldier on the move and shall not interfere with Soldier operations. Perform a tradeoff study of candidate configuration/options and identify best solution. The final report shall be a complete design of the proposed LIGHTNING System. The report shall delineate how the system will allow for proper use on the Soldier and interoperability with power scavengers and appropriate ruggedness. The report shall also...
provide an estimate of the cost, size, weight, system acoustics, system temperatures, system power generation, and any tradeoffs.

Provide prototype of or details of proposed solution that meets the light-weight (less than 3 Lbs. at greater than 30 W output) and small on-Soldier form factor size and power requirements. A prototype system will be bench-demonstrated in form-factors relevant to the Army’s needs, with key metrics including weight of the Soldier-worn power generation device, power transfer range, peak-power, frequency, and overall system efficiency. In order to be considered for this effort, the bidding firm must also show that they are capable of performing proof-of-principle experiments.

PHASE II: Based on the selected Phase I design, build a minimum of two (2) fully functional, rugged prototype of the proposed SPG system, then integrate and test it with Army provided power scavengers and recharging devices (UBC-Life; SIREN, SPM 622) as defined by the Project Manager Close Combat Squad (PM CCS) Ground Soldier Systems (GSS) – Soldier Power (SP) team and employ on and off the Soldier and verify operational performance to provide power. Demonstrate the capability of the LIGHTNING System to operate on and with existing Soldier gear and equipment (E.g. Radios and GPS systems – Government supplied) with minimal impact to Soldier or Systems performance. Submit a report detailing test and demonstration results. The report shall include the study of how the System will complement or impact Soldier operations and equipment. All software / firmware / Graphical User applications generated for the System shall be provided as open source information to the Government along with any input/output data/ICDs to / from the LIGHTNING System. Supporting data shall include analysis for LIGHTNING system’s performance throughout its lifecycle. Identify any other issues that should be addressed in Phase III like hardening the technology to survive Soldier environments (e.g. MIL-STD-810, MIL-STD-461, etc.), handling, and ease of use along with considerations for low-cost production processes for mass production.

PHASE III DUAL USE APPLICATIONS: In conjunction with PM CCS GSS SP, optimize the prototype fabricated in Phase II to commercialize the system and be rugged for operations in Tier 1 (most austere environments) mission operations and durable enough for Soldier fielding. Provide a transition path to DoD Program managers for use of this novel power system. The development of this LIGHTNING System also could have considerable commercialization potential for outdoor activities such as hiking and camping that do not have traditional power available.

REFERENCES:
1. Department of the Army Memorandum THRU General Robert W. Cone, Commanding General, U.S. Army Training and Doctrine Command, Fort Monroe, VA; Subject: FY12 Warfighter Outcomes (WFO) to Guide Science and Technology (S&T); Dated: 08 Jun 2011.
8. Integrated Soldier Power & Data System – Core Performance Specification (PM-SWAR-SPS-ISPDS-C Dated 27 June 2014) – Project Manager Soldier Warrior Soldier Systems & Integration, 10125
Kingman Road, Bldg 317, C18 Fort Belvoir, VA 22060-5820. Note: PM SWAR is now PM CCS located at 5966 12th Street, Bldg 1024, Fort Belvoir, VA 22060.

9. Published Conformal Battery Specification (MIL-PRF-32383/4): Base Spec and Slash 4:
   http://quicksearch.dla.mil/basic_profile.cfm?ident_number=277787&method=basic
   http://quicksearch.dla.mil/basic_profile.cfm?ident_number=279268&method=basic


KEYWORDS: Expeditionary Soldier Power, Internal Combustion Engine, Power Generation, DC Power, Lightening the Soldier Load, Operational Flexibility.
RT&L FOCUS AREA(S): general warfighting
TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: To develop innovative distributed tools for performing pre-execution on-console training to optimize flight test execution team readiness, and establish quantifiable metrics suitable for objective evidence.

DESCRIPTION: Increases in flight test complexity, geographically distributed test execution teams and accompanying growth in complexity of formal Launch Constraints and other test execution procedures drive the need for new and innovative test-execution team training tools and methods. An integrated training environment controller is required which can be deployed across the distributed execution team to support real-time anomaly insertion, track operator actions and assess team readiness for the increasingly complex flight testing programs.

The challenge is to develop a tool that is sufficiently flexible to model the ever increasing mission-specific flight test constraints which evolve through the Government’s requirement to produce realistic flight test events and push the developed systems to their maximum performance limits. This requirement, in turn, also impacts the required training cycle and forces a drastic improvement with the training realism and the resulting value of mission rehearsals. The specific challenge to be addressed is that the tools must codify mission-specific training metrics which can be logged automatically for post-rehearsal readiness assessments.

If successful, the software tools will benefit many military applications such as test directors and operators by ensuring the personnel are fully capable and prepared to execute test events which cost hundreds of millions of dollars to execute. The specific weapon and target platforms of interest for this topic are test targets for ground-based High Energy Laser (HEL) weapon systems, long range hypersonic weapons, and ballistic missile defense systems.

The objective software application for this topic is not specified as the government currently utilizes a small set of Monte Carlo trajectories to execute the simplistic training due to the lack of operator training tools. It is expected that the design be modular in nature and can be applied to a variety of range commercial and military testing applications. The offeror must include a demonstration system (software and some integration hardware) for performance demonstration during Phase II.

PHASE I: The phase I effort will result in the concept feasibility, architecture, design of the proposed solution, and demonstrate prototype components. The phase I effort shall include a final report including software requirements, system software architecture, software detailed design, and cyber-security approach.
PHASE II: The Phase I designs will be utilized to develop, integrate, interface, test and evaluate a breadboard system. The breadboard system design will then be modified as necessary to produce a final prototype. The final prototype will be demonstrated to highlight the suitability to representing the range flight systems and controls. A complete demonstration system inclusive of representative elements must also be provided by the offeror. TRL (Technology Readiness Level): TRL 5 - Component and/or breadboard validation in relevant environment.

PHASE III DUAL USE APPLICATIONS: Civil, commercial and military applications include training systems for commercial and military test ranges. High energy lasers and advanced propulsion systems can leverage this technology to ensure safe operations of flight vehicles by the use of this/these software tool(s) to train qualified personnel for range safety. The Phase III effort would be to 1) design and build a training system for long range precision fires applications in connection with multiple MRTFB test ranges and/or 2) design and build a target detection/tracking processor that could be integrated into the Army’s High Energy Laser Mobile Tactical Truck (HEL-MTT) vehicle for test targets as necessary. Military funding for this Phase III effort would be executed by the US Army Space and Missile Defense Technical Center.

REFERENCES:
2. White Sands Missile Range WSMR Public > RCC > Available Publications. (Year, Month Date of publication). Retrieved from https://www.wsmr.army.mil/RCCsite/Pages/Publications.aspx

TITLE: High-Power Tapered Amplifier Laser Diode Array With Active Phase Control Feedback Loop for Future High Energy Laser Weapons

RT&L FOCUS AREA(S): Directed Energy
TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a kilowatt class near infrared direct diode laser array based on tapered amplifier technology with emitter-level phase control for extracavity coherent beam combination.

DESCRIPTION: High-power, high brightness direct diode lasers exhibiting single mode performance and displaying high beam quality are needed to scale the output power of SWAP-constraint mobile high energy laser weapons by surpassing the fundamental efficiency limits of high energy fiber laser systems. Commonly the output power of diode lasers can be increased by increasing the semiconductor active area. However, a direct consequence is a degradation in the emitted beam quality, which severely limits laser beam propagation. Therefore, broad area diode lasers are not practical solutions for high energy laser weapons. Instead, solutions that can emit at a high power while maintaining excellent beam quality are needed.

At the single emitter level, tapered amplifiers have achieved some of the highest output powers (Watts) in the field of diode lasers at brightness levels of 1000 MW/cm(2)/sr, while maintaining near single mode beam characteristics and diffraction limited beam quality in the fast axis [1,2]. Efforts to improve the beam quality of the slow axis have achieved near diffraction limited slow axis performance, and external micro-optics can match the divergence angles and address astigmatism between the two axes. A tapered amplifier is driven by a high quality seed laser, which may be integrated into each amplifier element, or a single seed may supply multiple tapered amplifiers in an active master oscillator power amplifier (MOPA) architecture [3].

Realizing an array of tapered amplifiers to produce a high power laser (kW-class power, GW/cm(2)/sr-class brightness) poses two overarching challenges. First, the solution to construct a dense array, e.g. monolithically, needs to address thermal management, wall plug efficiency, seed geometry, and irregularities such as “smile” in the fabrication stages. Tradeoffs between array fill factor, external array symmetrisation and optics, as well as thermal management need to be considered in the context of SWAP and efficiency.

Secondly, a method to actively control the phase relationship between N elements, which is necessary to achieve predictable coherent beam combining (CBC) results at high combining efficiencies, needs to be developed. Indeed, the added complexity of phase control at each element may in turn decrease the complexity of the optical path from laser to telescope: beam control methods such as the use of adaptive optics to address atmospheric effects, fast steering mirrors, and associated mechanical and electronic control loops may be addressed by the laser itself through its ability to control the phase at each element at kilohertz speed.
PHASE I: Design the architecture and fabrication technique to construct a kW-class (>1kW) laser array based on tapered amplifiers. The design must include predictable wall-plug efficiency, beam quality characteristics, fabrication cost, tolerances and areas of risk. Furthermore, the design must be complete with a detailed description of the proposed CBC architecture including all hardware components from seed laser to phase detectors, packaging, as well as phase modulation and feedback algorithms to produce predictable and highly stable phase relationships between all elements of the diode array. The design must include a hardware solution for physically combining N elements into a single, coherent, high beam quality, high power laser beam.

PHASE II: Construct a kW-class (>1kW) laser array based on the design delivered during Phase I. To address uncertainty in cost for realizing such an array, at a minimum, a 500W array has to be delivered if the design clearly shows that scalability to over 1kW per array is straightforward, and does not pose additional technical challenges. The array shall be delivered with external beam combining hardware to demonstrate the ability to coherently combine all elements. For demonstrational purposes, the maximum level of constructive, and destructive interference in units of output power and coherence length shall be reported on to provide quantitative results for combining efficiency. Furthermore, the beam quality of the combined beam shall be characterized. Quantitative efficiency values related to the individual amplifiers, diode array, and CBC method shall be clearly identified.

PHASE III DUAL USE APPLICATIONS: Optical metrology, which is an emerging field as a non-contact measurement method for military and industry will benefit from a high power tapered array with phase control, which can open the door for electronic beam steering of lasers. Tapered amplifiers are needed for nonlinear research through second harmonic generation as well as for pumping of Raman or other solid state amplifiers, requiring high power and high brightness. Furthermore, a CBC tapered amplifier array will allow for amplitude modulation of the high power laser beam, which is very difficult with current state of the art high energy lasers.

REFERENCES:

KEYWORDS: Direct Diode HEL, tapered amplifiers, high-brightness diode lasers, phased locked lasers
TITLE: Photonic Crystal Surface Emitting Semiconductor Laser

RT&L FOCUS AREA(S): Directed Energy
TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop the design space for high-power, high-beam quality photonic-crystal surface emitting lasers (PCSELs) and demonstrate a set of PCSEL prototypes.

DESCRIPTION: High power diode lasers have been almost exclusively reserved to edge emitting diodes. However, edge emitting diodes bring about challenges with respect to mode quality, beam symmetry, and the combination of many diodes into high power diode arrays and modules. Surface emitting diodes such as the vertical-cavity surface-emitting lasers (VCSEL) have many beneficial properties to include advantageous mode quality, beam shape, absence of catastrophic optical damage COD. However, the output power of element emitters is on the order or milliwatts, hence, thousands or diodes need to be efficiently combined to generate high power laser beams. This leads to a complicated and challenging beam combination process.

Recently, photonic-crystal surface-emitting lasers (PCSEL) have emerged as potential solution that rivals edge emitting diode lasers in output power while maintaining radially high symmetric beam quality of approximately $M_2 = 1.1$ [1-3]. A properly designed and implemented square-lattice photonic crystal will produce a singularity point, which allows for single-mode two-dimensional wave coupling and hence, two-dimensional broad-area cavity modes for high power lasing. By coupling this two dimensional architecture to radiation modes outside the photonic crystal via diffraction, vertical emission, i.e. a surface-emitted output beam can be realized [4].

The design considerations for a PCSEL need to be explored and understood clearly to inform the trade and implementation space in the context of high energy laser weapons. These design considerations include selections in the photonic crystal structure and fabrication techniques, semiconductor layer design, materials and fabrication, beam mode quality and coherence properties as well as beam shape and divergence angle. Previous academic work promises PCSEL output power on the order of 1 Watt per emitter, and beam quality of $M_2 < 1.1$, which as a combination may outperform current state of the art edge emitting as well as surface emitting diode solutions considered for HEL weapons. Furthermore, forecasting technology advancements suggest that output powers of greater than 10W may be achievable without loss in $M_2$ performance. Additionally, the design freedoms associated with the crystal structure and electrode placement may allow for active beam steering [5].

PHASE I: Formulate the trade-space towards the design and development of high-power, high-beam quality PCSELs through a modelling and simulation (M&S) approach. The M&S approach will address photonic crystal structures, layer placement and respective thicknesses, geometries to couple from the two-dimensional cavity into free space for high-quality surface emission, choice of materials, and fabrication techniques and challenges. The deliverable will be a modelling and simulation tool to
investigate PCSEL performance and characteristics as a function of the aforementioned trade space, and two PCSEL solutions will be proposed for development and fabrication in Phase II.

PHASE II: Design and fabricate two separate PCSEL emitters that vary in their respective approach in terms of photonic crystal structure, layer structure and material choices, and fabrication technique. The PCSEL prototypes will be fabricated and delivered in a package similar to a development board to report on and allow for independent test and evaluation of various laser parameters to include mode quality, coherence, conversion efficiencies, thermal stability, etc.

PHASE III DUAL USE APPLICATIONS: Develop beam steering solutions to transition high power PCSEL technology into sensor applications such as automated driving, and free space high bandwidth telecommunication. Develop a high power PCSEL array towards the next generation high energy laser weapons.

REFERENCES:

KEYWORDS: Direct Diode HEL, high-brightness diode laser, surface emitting lasers