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ARMY
21.3 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

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/topics-app/ Specific questions pertaining to the Army SBIR Program should be submitted to:

Monroe Harden
Fundamental Portfolio 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 up to three DOD SBIR BAAs each year. Proposals not conforming to the terms this BAA will not be considered. Only Government personnel will evaluate proposals.

PHASE I PROPOSAL SUBMISSION

SBIR Phase I proposals have six Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume, Company Commercialization Report, Supporting Documents, and Fraud, Waste and Abuse training. Please refer to the DoD SBIR Program BAA for full details on the requirements of each proposal volume.

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. The Company Commercialization Report (CCR) allows companies to report funding outcomes resulting from prior SBIR and STTR awards. Information contained in the CCR will be considered during proposal evaluations.

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, the 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 DoDSBIRSupport@reisystems.com.

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 firmat 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 the DOD BAA.

21.3 Phase I Key Dates

BAA Closes, Proposal Due	See DoD BAA for Dates
Phase I Evaluations	25 Oct 2021 – 7 Jan 2022
Phase I Selections Announced	18 Jan 2022
Phase I Award Goal	21 Mar 2022*

**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, theCost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DOD Help Desk at DoDSBIRSupport@reisystems.com

For projects awarded in cycle 21.3, there will be **ONE window for submission** of Phase II proposals. A single Phase II proposal can be submitted by a Phase I awardee within one, and only one, Phase II submission window. 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 or Sequential 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 Phase II proposal submission window for Phase I contracts awarded under cycle 21.3 opens for submission on 1 March 2023 and closes on 31 March 2023.

Army SBIR Phase II Proposals have six Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume, Company Commercialization Report, Supporting Documents, and Fraud, Waste and Abuse training. Only the first four volumes will be considered for evaluation. 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 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 Submissionsite by clicking on the "Verify Technical Volume" icon.

Only the electronically generated Cover Sheet, Cost Volume, CCR, Supporting Documents, and Fraud, Waste and Abuse training are excluded from the 38-pageTechnical 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 the DOD 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 1 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 receivean 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.

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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 contractdocument, 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 employeeentering 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 (andseparate 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 contractorwith its UIC for the purposes of reporting this information);
  (7) Locations where contractor and sub-contractors perform the work (specified by zip code inthe 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 September30 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 theGovernment 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)

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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 two 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, then click the "SBIR" tab, and thenclick 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 processesresulting from such projects including intellectual property protections.

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

Alternatively, an SBIR firm may directly acquire the technical assistance services describedabove 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 objectiveof 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 proposalspecifically 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 profitor 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, aninvestor 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 notbe 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 forany other considerations.

NOTE: The Small Business Administration (SBA) is currently developing regulationsgoverning 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 assistancefrom 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. Listall 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 andany 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
- developedThe 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 21.3

Participating Organizations	Program Coordinator	Phone
Army Futures Command (AFC)	Casey Perley	716-754-6311
Armaments Center (AC)	Sheila Speroni	973-724-6935
Aviation and Missile Center (AvMC-A)	Dawn Gratz	256-842-3272
Aviation and Missile Center (AvMC-M)	Dawn Gratz	256-842-3272
Army Research Laboratory (ARL)	Francis Rush Nicole Fox	919-549-4347 919-549-4395
Army Test & Evaluation Command (ATEC)	Kendra Raab	443-861-9344
Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR)	Lauren Marzocca	410-395-4665
Chemical Biological Center (CBC)	Martha Weeks	410-436-5391
Engineer Research & Development (ERDC)	Melonise Wills	703-428-6281
Ground Vehicle Systems Center	George Pappageorge	586-282-4915
PEO Aviation	Randy Robinson	256-313-4975
PEO Command, Control and Communications Tactical (PEO C3T)	Meisi Amaral	443-395-6725
PEO Intelligence, Electronic Warfare& Sensors (PEO IEW&S)	Michael Voit	443-861-7851
PEO Missiles & Space	David Tritt	256-313-3431
PEO Soldier	Mary Harwood	703-704-0211
PEO STRI	Robert Forbis	407-384-3884
Space and Missile Defense Command (SMDC)	Jason Calvert	256-955-5630
Soldier Center (SC)	Cathy Polito	508-206-3497

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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 22060-6218; (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 http://www.dtic.mil.

Protest Procedures

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: usarmy.apg.ccdc.mbx.sbir-program-managers-helpdesk@mail.mil

Notification of Selection or Non-selection

Proposing firms will be notified of selection or non- selection status for a Phase I award or a PH II award within 90 days of the closing date of the BAA. The two individuals named on the Proposal Cover Sheet will receive an email for each proposal submitted from with instructions to retrieve their official notification of proposal selection or non-selection.

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 the DoD SBIR Program BAA.

4. SBIR Phase I proposals have six Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume, Company Commercialization Report, Supporting Documents, and Fraud, Waste and Abuse training. Please refer to the DoD SBIR Program BAA for full details on the requirements of each proposal 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 proposalsubmission 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 totalcost 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 ofcomplying 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 togovernment 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 satisfiesone 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.

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ARMY SBIR 21.3 Phase I Topic Index

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A21-101 TITLE: Modern, Safe, and Affordable Processes for Production of Energetic Polymers (BAMO-AMMO)

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

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: Develop safe, novel, and cost-effective processes for the commercial manufacture of energetic polymers (BAMO-AMMO) suitable for formulating advanced, high-performance materials.

DESCRIPTION: To achieve the goal of extending the range of current and future precision fire munitions for the US Army's mission of performance overmatch, materials with energy greater than currently available are necessary. One of the methods to increase overall performance of a propulsion system is the use of high energy thermoplastic elastomers (ETPEs). These materials are formed by linking two or more polymeric building blocks, one of which is typically crystalline in nature and one of which is amorphous, into a single polymer chain. The specific properties of a given ETPEs is controlled by a number of factors including characteristics of the building block molecules and linking agents, average polymer molecular weight, and distribution of molecular weights. ETPEs have been shown to have promising key properties such as good flame temperature, stability and performance. BAMO-AMMO, one of the ETPE material, an energetic block copolymer, offers desirable performance, good mechanical properties, high energy, is clean burning, and is chemically compatible with a wide range of materials such as nitramines. Significant efforts have been performed in developing BAMO-AMMO such as tailoring the "soft" AMMO and "hard" BAMO blocks of the copolymer to tailor the final mechanical properties. However, the current manufacturing processes for BAMO-AMMO prevent the ETPE from being affordable or manufactured with high throughput. The polymerization reactions need excessive amounts of reaction time (up to 96 hours) and extensive workup and isolation. The focus of this SBIR project shall include multidisciplinary research and development effort focusing on a robust, scalable and affordable manufacturing process for BAMO-AMMO and its precursors using modern technologies.

PHASE I: Develop and demonstrate lab-scale synthesis method (~25-50gms per batch) using novel processing concepts to produce BAMO-AMMO material. Material from each small batch will be further characterized to compare properties with legacy material. Study the material residue after burning of the selected BAMO-AMMO batch materials. Perform analysis of rheological and physical properties of the BAMO-AMMO materials at various temperature, humidity and treatments. Additional characterization tests will be performed including, thermal analysis, gel permeation chromatography (GPC), dynamic mechanical analysis (DMA), melt viscosity, Teflon adhesion test, and nuclear magnetic resonance (NMR). Other testing may be performed to determine specific safety properties and other performance or structural characteristics of interest. Complete feasibility studies at the laboratory scale will focus on the polymerization process: chemical process steps, isolation of product, and waste stream processing with particular emphasis on safety and throughput. Material produced from the proof of concept demonstration (25-50 gram scale) will be sent to the Army for further characterization to ensure results are consistent and meet expectations. Chemical stability, in addition to multi-ingredient compatibility (including nitramines and other oxidizers) will be assessed by methods such as Vacuum Thermal Stability (VTS) as outlined in MIL-STD-286C or equivalent.

PHASE II: Review the results from the Phase I feasibility study. Down select and optimize the synthesis process of the desired BAMO-AMMO material. Demonstrate the process by producing hundreds of grams of BAMO-AMMO in the scale of 250-500gms per batch according to desired material properties. Perform thermal and necessary safety testing for proper handling and shipping material to USG. Characterize BAMO-AMMO material properties and ensure results are consistent and meet expectations. In support with USG, formulate and produce propellant geometry using BAMO-AMMO to characterize final product for thermal analysis, mixing, rheological, mechanical, and combustion properties. Provide with the full process design for BAMO-AMMO manufacture and transition plan. Provide cost analysis on the synthesis process to manufacture BAMO-AMMO in larger quantities. The design and transition plan will guide Phase 3 efforts, which will focus on qualification of the material in propellant applications selected by the US Army.

PHASE III DUAL USE APPLICATIONS: If this program is demonstrated to be successful, this energetic polymeric material technology can be applied to various military applications. Military application includes propellants primarily for large caliber (60mm, 81mm, 105mm, 120mm, 155mm), medium caliber (20mm, 25mm, 30mm and 40mm) as well as small arms (5.56mm, 7.62mm and 0.50 calibers) ammunitions. The likely transition partner is the Joint Program Executive Officer for Armaments & Ammunitions.

REFERENCES:

1. Braithwaite, P.; Sanderson, A.; Wardle, R. “Optimization of BAMO-AMMO for gun propellants”, JANNAF conference, 2000.;
2. Sikder, A.K.; Reddy, S. “Review on Energetic Thermoplastic Elastomers (ETPEs) for Military Science” Propellants, Explosives, Pyrotechnics, 2013, 38, 14-28.;
3. Wardle, R.B.; Cannizzo, L.F.; Hamilton, R.S.; Hinshaw, J.C. Final Report “Energetc oxetane thermoplastic elastomer binders” AD-A278307, Thiokol Corporaton, 1992.;
4. "Thermoplastic elastomer-based low vulnerability ammunition gun propellants " US Patent#US4919737A; "High energy thermoplastic elastomer propellant" US Patent# WO1998021168A1

KEYWORDS: High Energetic Polymers, Energetic thermoplastic elastomers (ETPE), BAMO-AMMO

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A21-102 TITLE: Dynamic Characterization of Critical Material Properties

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics

TECHNOLOGY AREA(S): Materials, Sensors

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 development of high throughput techniques which can measure material properties in a variety of systems including aqueous slurries, molten organic mixtures, and consolidated pellets.

DESCRIPTION: Currently, many industrial processes for the US Army function as 'black boxes' as they are poorly understood from a dynamic sense. While inputs are known and outputs are well characterized, the process itself is not well monitored. This results in tremendous deficiencies, and overall a lower quality product for the Warfighter. This also contributes to the difficulties associated with transitioning new technologies to the Warfighter, as implementation is inhibited by an ignorance of how new materials behave when used with current manufacturing techniques. An additional difficulty is that many parameters critical for understanding and assessing them are difficult to measure, especially across a wide of variety of environmental conditions. This impedes maturation of new materials, as costly, time consuming testing becomes required at every developmental stage. This is especially relevant now, as the potential of some of the most advanced models is impeded by a lack of materials characterization. Succinctly, the development of new materials at nearly every technology and manufacturing readiness level is negatively impacted by a lack of high throughput characterization.

By measuring a suite of critical properties efficiently across a wide number of environments, these issues can be solved. At first, this would provide a boon to lab scale efforts, as they would allow a much broader number of materials to be examined and down-selected far more quickly than currently possible. This would make implementation of pilot scale-up to low-rate-production much easier by providing a far more comprehensive understanding of the materials in question. Furthermore, the technology can be implemented at these stages to function at first as a method of easing transition of novel materials, but later on as method of optimizing efficiency and functioning as seamless quality control. While not a requirement, it would be preferred if the developed probes operated under 'first principles' and therefore required little calibration to use with new materials. This would ensure that they have the broadest impact in the quickest manner, while minimizing cost.

These technologies are expected to have dramatic impact across a variety of industries. For example, pharmaceutical companies could use probes under the developed effort to speed the transition of new drugs. Ceramics and metals, especially those using nanomaterials, would also benefit. The plastics industry could use these types of online tools to replace much of the characterization they do offline. Oil and gas industries as well as new green energy technology such as solar cells and geothermal plants would also benefit, as they are constantly evaluating new materials, and must be able to do so while extrapolating performance to extreme environments.

VERSION 2

PHASE I: Design a lab scale system which can demonstrate the ability to measure the properties described previously over a temperature range of -100 C to 200 C. These results should be validated by comparison to literature values or by some other independent process which is widely recognized in the scientific and engineering disciplines. In general, accuracies of ± 5 % are desired. The system should be able to measure the following properties in the given ranges: porosity (from 0.1 % to 25 %), shear viscosity (1 Pa·s to 10^8 Pa·s), particle size (100 nm to 1 mm), phase changes (melt, glass transition, crystallization, change from one crystal order to another), the Anderson-Grüneisen parameters, the Grüneisen parameters, and the density of the material (0.1 g/cm^3 to 10 g/cm^3). The probes should be demonstrated to operate in common batch processes and continuous flow systems.

PHASE II: Test the system on a suite of materials of relevance to the US DoD. This includes nitrocellulose, aluminum, lead, HMX (Octogen), RDX (Hexogen), HTPB (Hydroxyl-terminated polybutadiene), CAB (Cellulose Acetate Butyrate), Viton, Teflon, copper and steel, but more will be identified and can be provided to the contractor at their request. The General User Interface (GUI) should be relatively straightforward and systems should be provided to the US Army for further testing and verification. These probes should be certified as explosion-proof, and shown to be resistant to environments with a pH of 4 to a pH 11. A user manual should be drafted.

PHASE III DUAL USE APPLICATIONS: Based on feedback from Phase 2, improvements will be made to the system to enable transition to industry partner/production facilities. This includes further improvements of user interface. Furthermore, demonstration of long-term stability of the system should be undertaken. This would include long-range studies which will measure the accuracy of the probes over long periods of time, and the demonstration of reliable usage over the course of a year. Limited maintenance for electronics and software will be allowed, but generally the probes should be used for longer periods of time without significant upkeep.

These technologies are expected to have dramatic impact across a variety of industries. For example, pharmaceutical companies could use probes under the developed effort to speed the transition of new drugs. Applications involving ceramics and metals, especially those using nanomaterials, would also benefit. The plastics industry could use these types of online tools to replace much of the characterization they do offline. This would be a boon for the oil and gas industries as well as new green energy technology such as solar cells and geothermal plants, as they are constantly evaluating new materials, and must be able to do so while extrapolating performance to extreme environments.

REFERENCES:

1. Mechanics of Materials, By Ferdinand Beer and E. Johnston and John DeWolf and David Mazurek, McGraw Hill 2012;
2. Particle Size Measurements, Henk G. Merkus, Technology and Engineering, Springer Science & Business Media, 2009;
3. Chemical Reactor Modeling: Multiphase Reactive Flows, Hugo A. Jakobsen, Springer Science & Business Media, 2008;
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5. Ultrasonic Testing of Materials, Josef Krautkrämer, Herbert Krautkrämer, Springer Verlag Berlin, 1990

KEYWORDS: Material characterization, particle size analysis, Grüneisen, viscosity, particle size, bulk modulus, density

VERSION 2

A21-103 TITLE: Easily Processed High Tg polymers

OUSD (R&E) MODERNIZATION PRIORITY: Space

TECHNOLOGY AREA(S): Space Platform, 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: Polymers are required which exhibit extremely high glass transition temperatures (> 350 C) but are soluble in commonly used organic solvents such as acetone, ethyl acetate, and chloroform.

DESCRIPTION: Novel munition systems currently must contend with extraordinary thermal demands. This has necessitated the development of polymers which can match the rigors associated with state of the art systems. Chiefly, they must maintain great strength and stiffness while under high thermal loads. In order to be processable, however, they must maintain high solubility levels in commonly used solvents so they can still be worked into desired shapes. For example, for many applications they must be able to be cast into thin films. Furthermore, if they can be easily processed, they could then be used in novel energetic formulations as binders. Here, they could impart great stability to energetic formulations, a critical goal in many novel munition systems which will put tremendous thermal load on energetic formulations.

Unfortunately, while not mutually exclusive properties, it appears as if many polymers with high glass transition temperatures exhibit poor solubilities. To further the difficulty of the problem, it appears, few, if any polymers currently available have a high enough glass transition temperature to satisfy the needs for the US Army. Therefore, new polymers are required with high glass transition temperatures, but these polymers must also be easily molded into desired shapes, which means they must have high solubility in commonly used organic solvents. They should also exhibit superior mechanical properties through a wide temperature range, as envisioned applications will required relatively high stresses, and often, very high strain rates.

These polymers must be manufactured in an environmentally friendly manner, and should be sourced domestically. When possible, issues with foreign/sole sourcing of precursor materials must be addressed. If successful, it is expected this effort would spawn off numerous other programs, for example MANTECHs, and this effort should produce sufficient information to pursue follow on efforts.
While interesting in other cases, this effort should NOT focus on use of additives such as nanoclays, carbon nanomaterials etc. The goal of this effort is to obtain the desired properties purely with the polymer. For many use cases, the additives would be a hindrance.

PHASE I: Develop polymers at the laboratory scale (~5 grams) and characterize solubility in the following solvents: acetone, ethyl acetate, tetrahydrofuran, ethanol, water, methyl ethyl ketone, methanol, toluene, acetonitrile, and heptane. The polymers should exhibit significant solubility in at least one organic solvent, preferably two or more, and they should be insoluble in water. Important thermal properties such as the glass transition temperature, crystallization temperature, and bulk modulus across a wide temperature range should be reported. The chemistry of the polymer should be mostly optimized at this point.

PHASE II: Polymers will be produced in the 100s of gram scale. Here the production of the polymers will be optimized, and any issues with the supply chain must be addressed (such as sourcing precursor materials from foreign and/or sole sources). Pricing of the polymers will be estimated under the assumption of an annual buy of ~100 Kg. The polymer properties should be optimized at this phase for the most likely applications, to be further explored in phase 3. Molecular weight is a key consideration in this phase. Aging studies should be conducted at this stage, to determine the suitability for long term usage. High strain testing of the properties of these materials should be conducted, but the US Army will be able to provide such characterization at this stage if required. The polymers should now be ready for use in engineering type tests, where they should be provided to the US DoD in the desired configuration. The US DoD will require 500 grams of each polymer for further evaluation in this phase.

PHASE III DUAL USE APPLICATIONS: Kilogram scale quantities of the 1-3 downselected polymers will be produced to support identified applications of interest. The polymers must be processed into a form usable for the US government. The polymers must be delivered to a US DoD installation, or a US DoD funded contractor before the end of project for a full scale evaluation. At this point, engineering tests should be performed on the polymers in the desired system, and if issues arise, further customization might be required.

High Tg polymers also offer a number of advantages in numerous industries, with the most dramatic example being those in space. This is because high Tg polymers are generally speaking offer extremely good strength to weight ratios, while maintaining properties across a wide temperature range. They are even useful for ‘exotic’ propulsion such as those using solar sails. A significant advance in high Tg polymers, therefore, should attract commercial interest as well.

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1. Disordered Materials: An Introduction by Paolo M. Ossi, Springer-Verlag Berlin Heidelberg, 2006;
2. Principles of Polymerization, Fourth Edition, George Odian, John Wiley & Sons, Inc. 2004;
3. Physical Properties of Polymers Handbook, James E. Mark, ACS Professional 1994;
4. The Glass Transition, Relaxation Dynamics in Liquids and Disordered Materials, E. Donth, Springer 2001;
5. Relaxation in glassforming liquids and amorphous solids, C. Austin Angell, Kia L. Ngai, Gregory McKenna, Paul F. McMillan, Steve W. Martin, Journal of Applied Physics 2008

KEYWORDS: Polymers, High Glass Transition, Thermally Stable, Solubility, Strength, Stiffness, Mechanical Properties, High Crystallization Temperature

VERSION 2

A21-104 TITLE: High-pressure pumps with minimal mechanical interfaces for low lubricity fuels

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Design, develop, and demonstrate innovative methods of pressurizing low-viscosity and low-lubricity fuels for delivery to high-pressure fuel injection systems that avoid or reduce sliding mechanical interfaces vulnerable to inadequate lubrication.

DESCRIPTION: High pressure common rail (HPCR) injection systems are used in internal combustion (IC) engines for several Army aviation and ground engines to deliver necessary propulsion power under harsh operating conditions. The HPCR IC engines and their components are designed for diesel fuels, however, they are typically operated with F-24 jet fuel by the US Army and other DoD branches. The properties of F-24 that are important to HPCR IC engine operation vary widely, such that some fuels that meet F-24/JP-8 specifications[1,2] may cause premature failure of HPCR fuel delivery components. Further, tactical independence of US Army units requires ability to operate outside of the established supply chains that provide fuel within established specifications. The broadening of the allowable fuel-property envelope will increase the ability of fast-moving, forward operating units to use the fuel resources that are immediately available in their environment. HPCR fuel pumps are sensitive to the lubricity of the fuels that they are pumping and are liable to fail prematurely when fuel lubricity falls below those of diesel and additivized jet fuel.[3,4] Fuel lubricity is based on chemical and rheological properties (viscosity) and can vary widely between diesel, jet fuel, synthetics, ethanol, and gasoline. Current high-pressure fuel pumps typically use cylinder-piston and cam designs that undergo sliding, reciprocating, and/or intermittent contact motions with significant loads at the points where various components come into physical contact. The vulnerabilities of these pumps is largely due to inadequate lubrication at those sliding and impacting mechanical interfaces combined with the tight tolerances that are needed to reach the desired fuel pressures. Innovative concepts and methods are sought to reliably pressurize low-lubricity fuels to high pressures of at least 2,500 bar while providing adequate flow. The resulting pump design is expected to increase robustness and reduce vulnerability to varying fuel properties by avoiding materials failures from inadequate lubrication of sliding and impacting mechanical interfaces by the working fluid. The target for the pump design are HPCR IC engines from commercial engine manufacturers used in class III unmanned aviation systems (UAS) and small-to-medium manned and unmanned ground systems (20 to 350 horsepower) for operation on standard military fuels (F-24, JP-8) and lower lubricity fuels (synthetic, ethanol blend, etc.).

PHASE I: Formulate details of proposed pumping method that eliminates vulnerability to low lubricity fuels through novel designs, materials, and operational concepts that eliminate sliding and impacting interfaces, or reduce their severity (sliding speed and distance, contact pressure, etc.) and number significantly. Proposed methods to produce the required pressure and fluid flow rate may use a single stage or multiple stages, however, any method and surrounding design must significantly reduce the number and harshness of mechanical interfaces from current HPCR pump designs. Possible methods of producing pressurization and flow are centrifugal motion, magnetic fields, solid-state compression, and microfluidics, but solutions are not limited to these methods. Develop design of major pump components and concept of how they work together to achieve compression and flow while minimizing sliding mechanical interfaces. Demonstrate feasibility of pumping method(s) to meet the required pressure and flow metrics in Phase II in a conceptual pump design through a comparison of instrumented benchtop experiments and analytical and/or numerical modeling/simulation. Determine estimated power requirements of design. Analytically/numerically determine contact pressures, stresses, and sliding speeds of any sliding or impacting mechanical interfaces and provide an assessment of damage vulnerability to lubrication with low-viscosity fuels. Deliverables are the conceptual pump design, quantitative feasibility results, power requirements, and vulnerability assessment.

PHASE II: Finalize component and pump designs from Phase I. Fabricate components and ensure expected operation through testing and comparison to feasibility model from Phase I. Integrate components together into working prototype. Demonstrate reliable operation of prototype using conditions for the North Atlantic Treaty Organization Allied Engineering Publication 5 (NATO AEP-5) standard (400 hours endurance plus before and after performance runs) on two fuels provided by the Army, F-24 jet fuel and one hydrocarbon fuel with no lubricity additives of 1 centiStoke viscosity at 40 °C, with the following requirements: simultaneously achieve at least a pressure of 2,500 bar (36,260 psi) at a flow rate exceeding 1.3 liters/minute; digital control of pump pressure and flow; use a readily-available vehicle power source (12- to 28-V electrical power, mechanical power on shaft); dry weight of less than 15 lbs.; combined length, width, and height of less than 40 inches. Provide evidence that pump could achieve operation for 3000 hours with no maintenance to meet typical IC engine overhaul intervals through accelerated endurance testing with start/stop cycles and flow rate variations. Deliver a working prototype to CCDC Army Research Laboratory for evaluation.

PHASE III DUAL USE APPLICATIONS: Integrate prototype fuel pump into a HPCR IC engine from a commercial engine manufacturer in the 20 to 350 horsepower range and conduct engine tests of prototype with both a standard military fuel and a low-lubricity fuel. Such engines are also relevant to the multi-billion-dollar markets for lightand medium-duty commercial transport vehicles, farm equipment, and construction/warehouse equipment (cranes, loaders, etc.), as well as power generators in remote locations. A successful demonstration of a high-pressure pump tolerant to widely-varying fuel properties would enable flexible fuel standards and open up the widespread use of synthetic and alcohol fuel blends to meet increasingly stringent US and international fuel use standards.

REFERENCES:
1. [1] Department of Defense Standard Practice Quality Assurance/Surveillance for Fuels, Lubricants and Related Products, MIL-STD-3004-1; NATO Standard AFLP–3747, “Guide Specifications (Minimum Quality Standards) for Aviation Turbine Fuels (F-24, F-27, F-34, F-35, F-37, F-40, and F-44),” Edition A, Version 1.;
2. [2] Detail Specification: Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37), MIL-DTL-83133J, 16 December 2015.;
3. [3] J.K. Klein, “PROPULSION AND POWER RAPID RESPONSE RESEARCH AND DEVELOPMENT (R&D) SUPPORT Delivery Order 0011: Production;
4. [4] G.R. Bessee, S.A. Hutzler, E. Frame, D.M. Yost, G.R. Wilson, N. Jeyashekar, and A.C. Brandt, “PROPULSION AND POWER RAPID RESPONSE RESEARCH;
5. [5] D.M. Yost, A.C. Brandt, and G.T. Hansen, “RAPID RESPONSE RESEARCH AND DEVELOPMENT (R&D) FOR THE AEROSPACE SYSTEMS DIRECTORATE,;
6. [6] D.M. Yost and E. Frame, “Rotary Fuel Injection Pump Wear Testing Using a 30%/70% ATJ/F-24 Fuel Blend,” U.S. Army TARDEC Fuels and Lubricants Research

KEYWORDS: Fluidics, Lubricants and Hydraulic Fluids, Fuels, Reciprocating and Rotating Engines, Fluid Mechanics, Mechanics, Thermodynamics

VERSION 2

A21-105 TITLE: Unmanned aerial system for organic squad-level situational awareness

OUSD (R&E) MODERNIZATION PRIORITY: Control and Communications

TECHNOLOGY AREA(S): Electronics

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OBJECTIVE: Develop an unmanned aerial system (UAS) airframe (< 150 g) with extremely low SWAP-C to support squad-level situational awareness. Tactical ground control station and payload development are outside of scope.

DESCRIPTION: The Army is currently attempting to field personal UASs for organic squad-level situational awareness and understanding (SA/SU). However, in the sub-150 g space, there are few if any options which meet all of the needs of the Soldier, and carry a substantial cost. Clearly, there is need for disruptive innovation to fold additional capabilities into a lower SWAP-C airframe. An airframe below 150 g is an Army Key System Attribute threshold, with an objective of 25 g. The airframe must have a payload capacity of ≥ 5 g, although payload development is outside of the scope of this effort (minimally, a "dummy" payload should be used). Visual and audible signature must be extremely low: it is an Army Key Performance Parameter that the audible signature not exceed 40 dB at 30 m. The UAS must have a flight time of 20–40 minutes. The UAS shall be capable of flight in sustained 15 knot winds and survive gusts of 20–30 knots.

While development of an appropriate radio may fall outside of the scope of this effort, the airframe should minimally incorporate a COTS radio for demonstration purposes. In this case, it shall be capable of later integrating a radio with 900–1500 m line of sight and 300–600 m non-line of sight (-30 dB) range, encryption, and live video feed. That is, the airframe shall possess appropriate SWAP allowances on the system level to incorporate such a radio.

Desirable features include threat detection and cueing; cursor on target; GPS and GPS denied operations; ability to integrate with ATAK/Nett Warrior (Android Tactical Assault Kit) and Adaptive Squad Architecture; obstacle avoidance; and GPS-denied return to home. Many or all of these features are likely beyond scope of this effort, but the airframe shall include appropriate hardware (e.g. processors, memory) to allow feature implementation without hardware change to the UAS. Maintenance shall be performed by the user and without special tools whenever possible. Operating temperatures are ≥ 0–20°C and ≤ 40–50°C and storage temperatures are (-30)–55°C. Ease of use and high mean time between essential function failure and system abort are important. Ultimate manufacturability of the UAS and materials/component selection are an important consideration during this development effort for keeping final unit costs low.

PHASE I: Develop an initial concept design to meet the requirements above. Perform an analysis of key system-level design trade-offs (e.g. how does optimizing for one requirement such as range affect other requirements, such as payload capacity). Provide a high-level bill of materials for key components in the design, and consider potential suppliers. Deliver draft CAD or other designs/models for your concept, and discuss technical and commercial feasibility.

PHASE II: Refine the design from Phase I using a detailed analysis of system trades and input from appropriate stakeholders. Fabricate, test, and deliver at least one prototype airframe meeting the above requirements, along with any supporting hardware (e.g. ground control station) and user manuals. Deliver a detailed plan to integrate any desired features into future designs which could not be included into the Phase II delivery prototype.

PHASE III DUAL USE APPLICATIONS: As appropriate, partner with relevant suppliers and/or prime contractors. Further develop the UAS and relevant sub-components to meet all of the desired specifications, and integrate the UAS into a low SWAP-C tactical kit with everything required to operate the UAS (e.g. ground control station, spare components, display, etc.). Develop firmware and interfaces required to meet sensor interoperability protocols for integration. Determine best system integration path as a capability upgrade for a relevant Army Program of Record.

The desired end state is a UAS providing SA/SU to the Squad or first responder with low/no cognitive burden and user input. That is, the Soldier should not be taken out of the fight (head up, hand on weapon), and the system should be fully integrated with the rest of his kit and network. Squad-level SA could then be propagated through to higher echelons as desired. This allows the individual Squad to know what is around the next corner or over the next hill, assist with building and route clearance, and provide life-saving real-time local intelligence.

Commercially, this technology has many applications for first responders. Police agencies can make use of it in many of the same ways as would the DoD. It would also be useful for search and rescue, especially in areas where it is difficult or dangerous for first responders to reach. A thermal payload, for example, would allow fire fighters to assess buildings and rooms before entry, and allow for much easier location of people via their thermal signature. Fitted with appropriate payloads, it could also discover chemical, biological, nuclear, or other threats, such as near a chemical spill or reactor meltdown.

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2. SAM.gov. "Soldier Borne Sensor OTA RWP," https://beta.sam.gov/opp/4af8d1483d1a4e2faa290ee748416779/view (2020);
3. Market Watch. "FLIR Systems Awarded $39.6 Million Contract for Black Hornet Personal Reconnaissance Systems for U.S. Army Soldier Borne Sensor Program," https://www.marketwatch.com/press-release/flir-systems-awarded-396-million-contract-for-black-hornet-personal-reconnaissance-systems-for-us-army-soldier-borne-sensor-program-2019-01-24 (2019);
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KEYWORDS: UAS, UAV, drone, squad, soldier lethality, situational awareness (SA), situational understanding (SU)

VERSION 2

A21-106 TITLE: Reconfigurable Navigation Sensors and Optimized PNT Solutions for Ground Combat Systems

OUSD (R&E) MODERNIZATION PRIORITY: Control and Communications, Autonomy, Artificial Intelligence/Machine Learning

TECHNOLOGY AREA(S): Sensors, Information Systems, Electronics, Ground Sea

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 design goals are :
- To develop multipurpose Positioning, Navigation, and Timing (PNT) sensor that can be reconfigured in realtime or near realtime to correspond with various threats to PNT signals.
- To optimize PNT sensor configurations for Ground Combat PNT system that is capable to automatically deploy corresponding PNT capability to mitigate the emerging threats.
- To leverage Modular Open Systems Approach (MOSA) and C5ISR/EW Modular Open Suite of Standards (CMOSS) architecture for hardware and software interfaces of the new developing sensor.

DESCRIPTION: There is currently no single silver bullet to solve the PNT problem for Ground Combat Soldiers in a GPS challenged environment. PNT systems of the future will be expected to utilize an array of PNT sensor inputs in order to provide an assured-PNT solution that is resilient from adversarial threats, interference, and other challenging environments. A layered approach having multiple PNT sensors including those rooted in traditional RF signals from space and terrestrial systems alongside emerging complementary PNT sensors is viewed as having greater potential for providing a military PNT solution at a level of assurance and integrity that is not currently found with GPS (reference 1). Beside a military GPS receiver and MEMS IMU, for example, a combat vehicle in the future may be equipped with additional PNT technologies such as Multi-GNSS, RF Ranging, EW sensors, Vision Aided Navigation, SOoP, AltNAV, Celestial Navigation, etc. An identified challenge of a layered sensor fusion approach in future PNT systems is the ability to manage and assess large amounts of sensor data in real-time to determine how the PNT system can optimally configured while experiencing complex and emerging threat scenarios. Another significant problem for the multi sensor solution is the limitation of military platforms to be able to equip a large amount sensors with minimal impacts performance of existing systems/subsystems as well as constrains for SWaP_C. For example, a future vehicle PNT systems will comply with the C5ISR/EW Modular Open Suite of Standard (CMOSS) and PNT sensors will be made in card form factor for a common chassis. Under the OpenVPX configuration, however, there will be limited slots for PNT sensors. Some of the PNT sensors in future will be hardware agnostic or have similar hardware designs that can be retasked with a different software load. Many sensors and systems will have intelligent deep-learning architectures requiring inherent configuration flexibility and advanced processing schemes (reference 2). Thus Reconfigurable PNT Sensors will be highly valuable along with a better choice of sensor fusion algorithm to optimize platform SWaP_C as opposed to deploying all PNT sensors concurrently which may not always be needed for a given mission (reference 3). The US Army is requiring future PNT systems to comply with MOSA where all PNT sensors will be designed modularly and work as truly plug and play sensors for the purpose of increasing interoperability and reducing costs, including those of future enhancements, and capturing the largest amount of industry innovation. Such a system would benefit from an optimization algorithm having Reconfigurable PNT Sensors enabled by software defined receiver (SDR) technology or other advanced signal processing methodologies that can efficiently and effectively provide real-time signal monitoring, analysis, and then reassign PNT sensors/resources to counter the detected threat with optimized configuration for the PNT system.

PHASE I: Using modeling, simulation, and experiment to determine the technical feasibility of the design goals described above and provide a specifications for the potential product in the end of this phase. The study in phase I should focus on a feasible approach to design multitasking or reconfigurable PNT sensor and to investigate optimal configurations for the developing sensor for mitigating PNT threats.

PHASE II: Develop the system prototypes based on the specifications and hardware/software identification found in from phase I. Demonstration system capability in TRL 5. Evaluate and provide the test results of the system prototypes to the government POC. Deliver five units of the developed prototypes to the government for evaluation, including all hardware and software necessary to operate and collect data from the delivered units.

PHASE III DUAL USE APPLICATIONS: Modify design based upon T&E results from Phase 2 to achieve a better small size, weight, and power (SWaP) system applicable to the mounted platform and comply with CMOSS architecture. Transition the technology to the U.S. Army. Integrate this technology into the PM PNT Mounted System and apply the new developing technology to the commercial market.

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KEYWORDS: PNT, Reconfigurable Sensors, Optimized, MOSA, CMOSS, GPS Challenged Environment, Assured PNT, SDR

VERSION 2

A21-107 TITLE: Chip-Scale Optical Receivers for Communications

OUSD (R&E) MODERNIZATION PRIORITY: Control and Communications

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop a small SWAP-C (chip-scale) optical receiver that overcomes current limitations such as field-of-view (FOV) and pointing and tracking (PAT) enabling communications for highly mobile vehicular and personal/on-body applications.

DESCRIPTION: The radio frequency (RF) spectrum, relied upon for wireless communications, is increasingly congested and subject to interference that reduces system performance. Obtaining the bandwidth necessary for the high data rates demanded by modern applications is extremely expensive within licensed bands, and permissible use of the unlicensed bands entails various design restrictions. Free space optics (FSO) systems that can communicate using lasers eliminate these problems since the optical bands are unregulated, and the extreme directivity of lasers prevent interference with nearby receivers. Furthermore, the large amounts of available bandwidth with this approach can offer very high data rates.

Unfortunately, while current commercially available FSO systems are suitable for fixed-site point-to-point applications with mast/tower-mounting, they are unsuitable for highly mobile applications with stringent size, weight, and power (SWAP) requirements. Additionally, the high-cost of FSO makes it impractical to field in very large quantities for military use and rules out potential civilian applications. Photonic integrated circuit (PIC) based FSO address all of these problems. Designed to be fabricated on an integrated circuit, PIC-based FSO can achieve size and weight reductions of multiple orders of magnitude relative to traditional FSO designs, and, when fabricated in production quantities, the costs of these PICs are minimal compared to FSO system component costs. In addition, because optoelectronic techniques enabling extremely rapid beam-steering can be used instead of mechanical steering, chip-scale systems can support on-the-move applications. Because of these capabilities and attributes the use of chip-scale FSO holds great promise for incorporation into networks as a means to alleviate the growing demand for RF spectrum while providing high data rate communications in a low SWAP-C design. Although chip-scale FSO components have been fabricated and demonstrated at various levels of maturity, additional development of the components and receiver design is needed in order to realize the promise of the technology. Current designs are limited in field-of-view (FOV) especially across wide bandwidths and implementation of high-speed pointing and tracking (PAT) is limited. C5ISR Center seeks the design and development of a chip-scale optical receiver that overcomes these challenges and enables low SWAP-C high data rate communications for highly mobile applications. In particular, C5ISR Center seeks a wide FOV (>= 45 degrees) wide-bandwidth (1 – 10 GHz) receiver capable of pointing and tracking and high rates (<= 500 us slew time across FoV). This includes significant increases in field of view in both azimuth and elevation planes across high bandwidths (e.g. 1 – 10 GHz or higher) as well as the ability to support high-speed beam-tracking, node acquisition/network entry, and angle of arrival calculations.

Work under this SBIR aligns with Army network S&T investments, including the Nova Specter project.

PHASE I: During Phase I the selected company(s) will design a chip-scale optical receiver capable of beam-tracking for highly mobile applications (e.g. vehicles, drones). The design must support wide bandwidths (at least 1 GHz and ideally 10 GHz) over a wide field-of-view (>=45 degrees in azimuth and elevation) in a compact form-factor (<= 1 cm^3) and have a clear and well defined path towards full 360 degree coverage. A pointing and tracking (PAT) mechanism will be designed with high slew rates (<=

500 us across FoV) that maintains low probability of detection and does not incorporate a side-channel or locator beacon. For eye-safety, designs must operate between 1200 nm – 1700 nm. A report documenting the design will be delivered to the government at the end of Phase I.

PHASE II: The Phase II effort will fabricate the chip-scale optical receiver and incorporate it into a demonstration/prototype communications system capable of demonstrating the ability to beam-track while sending high data rate communications (>1 Gbps). The optical receiver and demonstration/prototype communication system shall be delivered to the government at the conclusion of the Phase II effort along with a user's guide and an interface control document documenting the physical, electronic, and signaling interfaces necessary to incorporate the optical receiver into a third party design.

PHASE III DUAL USE APPLICATIONS: The Phase III effort will focus on commercialization of the technology, which could include civilian applications such as wireless access networks or drone communications. This will entail maturing and optimizing the chip-scale receiver from performance, cost, and ruggedization standpoints. This will also necessitate an innovative packaging design that incorporates a protective layer(s)/housing to prevent damage to the optical components and minimize the impact/likelihood of dirt, debris, condensation, water, or other obfuscating substances as well as scratches, cracks, or other damage to the protective covering.

The Phase III system will produce a compact optical receiver with impactful capability for both Army/DoD and civilian applications. For the Army/DoD FSO based communications will enable significant advancement in network capacity and improvements in low probability of detection (LPD). This can be used for air-to-air, air-to-ground, as well as ground-to-ground applications such as inter-vehicular communications. The lack of spectrum approval required for the use of FSO will represent an enormous time savings for spectrum managers, and the ability to use optical spectrum for a much wider range of communications will enable RF spectrum to be conserved for where it is most needed (e.g. non-line-of-sight links). In the civilian sector chip-scale optical communications holds tremendous opportunities. Billions of dollars are spent by commercial companies to secure the use of RF spectrum. The ability to use the optical spectrum instead which entails no spectrum costs, can therefore save enormous amounts of money. In addition to communications, certain optical receiver designs can also be applied towards LiDAR, which is a key component in some approaches to autonomous vehicle technology.

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KEYWORDS: Communications, Optoelectronics, Photonics, Photonic Integrated Circuits, Optical Phased Arrays, Free Space Optics

VERSION 2

A21-108 TITLE: Real Time EW Receiver Surrogate (RTERS)

OUSD (R&E) MODERNIZATION PRIORITY: Control and Communications

TECHNOLOGY AREA(S): Sensors, 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: Develop and build a portable Real Time Electronic Warfare Receiver Surrogate (RTERS) prototype with a set of hardware, firmware and software of a simulated EW radar receiver and display to show the effects of the countermeasure techniques.

DESCRIPTION: Battle damage assessment of Non-U.S. EW systems are hard to come by for the evaluation of the effectiveness of U.S. Electronic Attacks (EA) signals of an airborne EW system in a real time scenario. EW receiver surrogates are available to display normal radar signals on a Plan Position Indicator (PPI) but it cannot display the real time effects under the influence of EW techniques. The RTERS will evaluate EW techniques and Electronic Intelligence (ELINT) information as a surrogate radar receiver system when non-U.S. threat systems are not available. The RTERS prototype shall perform two major functions. The RTERS shall able to receive the proper signals of a CW, modulated waveforms and pulse radar information and stored these parameters in the prototype for comparison with the configured parameters in real time. The simulated radar display shall include the range and target indication display with regular radar signals. The second function shall show the effects on the simulated PPI when countermeasure signals are presented at the RTERS antenna inputs. The PPI shall display the EA effects on the simulated receiver display based on the EA techniques, dynamic changes in real time and the signal parameters that caused the effects are also overlaid on the same display in real time simultaneously.

The RTERS prototype shall include but not limited to the ability to receive, process and display radar signals from L, S, C, X and Ku bands. The usage of Commercial-Off-The-Shelf (COTS) Software Define Receiver (SDR) and portable real-time spectrum analyzer & monitoring receiver instrumentation for prototype design are encouraged to minimize lengthy RF circuits and RF subsystem designs. The prototype shall have the capability to accept and to process the Red hawk framework plug-ins and RaptorX framework plug-ins to demonstrate developed applications.

The prototype physical configuration shall include but not limited to a receiver/ processor, a display, a mouse, a keyboard, and a Double Layer DVD RW drive to perform command, control, data exchange and data storage of the RTERS system. For operation security, the prototype memories of the system shall be accessible and removable from the front panel of the system. Once the memories of the system are removed, RTERS shall be inoperable. No data, firmware and software can be retrieved from the RTERS prototype. The total system weight shall be less than 25 lbs. The system shall operate on a 120 volts AC household outlet.

The prototype receiver system shall include multiband antennas to receive the required radar frequency band signals. The antennas shall have a 360 degree field of view. The antenna subsystem shall able to scan 360 degrees continuously through mechanical and/ or electronic means to receive the proper radar signals. When the prototype system operates in synchronized mode with the simulated emitter, the prototype receiver system shall able to switch off the receiver antennas function during simulated emitter transmission period to a avoid co-site interference or high power transmitted signals damage to the receiver. For demonstration in an anechoic chamber, the prototype receiver is outside of the anechoic chamber. The antennas are placed inside the chamber, the cable separation could be as long as 25 feet from the receiver. Compensation of the signals are required to avoid signal power losses over the cables. The prototype receiver shall have the capability to process incoming radar signals and countermeasure signals continuously. The prototype system shall able to store 10 seconds or more of real time signals with a bandwidth of 500MHz or wider bandwidth signals. The stored signals shall be labeled for data retrieval in real time. The porotype system shall provide demodulated In-phase and Quadrature component (I/Q) digital signals for external RF recording.

The RTERS prototype shall have the interfaces to synchronize with GPS timing and external emitter simulator timing to perform real time operation. The prototype shall able to operate with Low-Voltage Differential signaling (LVDS) interface to connect to real time RF recorder for events recording. The system shall have Display Port interface connector and High-Definition Multimedia Interface (HDMI) connectors for external secondary display. The system interface shall have Secure Digital (SD) memory slot for down load and revise of configuration profile of 128 Gigabytes (GB) of data and files. The prototype system shall able to network through Bluetooth, Gigabit Ethernet interface and regular Local Area Network (LAN) interface.

PHASE I: The Phase I RTERS prototype system development shall provide the following results in a report:

i. Identify and define the technologies, COTS systems and components that could support the design and built the RTERS prototype.
ii. Provide a concept hardware, firmware and software design of the RTERS prototype system.
iii. Perform an analysis of the system performance
iv. Provide the outline feasibility of producing a demonstration of RTERS in phase II, and will outline demonstration success criteria in Phase II

PHASE II: The Phase II program shall continue with the phase I concept to design and fabricate RTERS prototype system for a successful demonstration of the system requirements. The phase II program shall include:

i. Develop, demonstrate, and validate the RTERS design concept of Phase I
ii. Implement the best approach from Phase I into hardware and software system
iii. Establish performance parameters through experiments and prototype fabrication
iv. Develop, test, and demonstrate the prototype design
v. Define field test objectives and conduct limited lab testing
vi. Construct and demonstrate the operation of the RTERS prototype
vii. Demonstrate the prototype in accordance with the test objectives
viii. Provide a monthly report with detailed technical progress and program expenses
ix. Provide a plan for practical deployment of the proposed commercial applications

PHASE III DUAL USE APPLICATIONS: Phase III of the prototype system will be oriented towards technology transition to Acquisition Programs of Record and/or commercialization of the technology. In Phase III, the contractor is expected to obtain funding from non-SBIR government sources and/or the private sector to develop or transition the prototype into a viable product or service for sale in the military or private sector markets.

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3. Pelan, J.D., "Modular Multi-Signal Tracking Pulse Descriptor Word (PDW) Generator with Field Programmable Gate Array (FPGA) Implementation, Wright State University Thesis paper, 20016", https://corescholar.libraries.wright.edu/etd_all/156;
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KEYWORDS: Electronic Attack, Electronic Warfare, radar, ELINT, EW surrogate receiver, plan position Indicator, multiple display screens, Pulse Descriptor Words, data comparison and validation, analog waveforms, pulse waveforms, Wideband antennas and SDR.

VERSION 2

A21-109 TITLE: IoT Network Access Control

OUSD (R&E) MODERNIZATION PRIORITY: Cybersecurity

TECHNOLOGY AREA(S): Sensors, Information Systems

OBJECTIVE: Develop & demonstrate a decentralized, secure, low power, Internet of Things (IoT) network architecture where every device on the network is uniquely identified, authenticated & authorized access, over standard wired and wireless protocols.

DESCRIPTION: This effort will research new and existing models for uniquely identifying devices and models for granting access to authorized devices and preventing rogue IoT devices from gaining access. The innovation for this Topic is the security that network access control (NAC) introduces. NAC ensures that every device is uniquely identified, Authenticated & then authorized. Commercial IoT implementations are focused on connectivity & convenience. Think of the numerous sensors in the tactical environment. How are they being uniquely identified? How can they be distinguished from malicious sensors or IoT devices? This topic addresses capabilities outlined in NIST's IoT Device Cybersecurity Core baseline publication, NISTIR 8259A, specifically, unique identification and logical access control.

PHASE I: Identify the minimum performance parameters for an IoT network in constrained tactical networks. Generate a proof of concept design/breadboard demonstration of IoT devices that are securely and uniquely identified, authenticated & authorized for access to this conceptual network. A report documenting the Proof of concept (POC) design will be delivered to the government at the end of Phase 1.

PHASE II: Demonstrate a dynamic, decentralized, network access control implementation on IoT devices. Demonstrate ability to add/join/verify new IoT devices to the network on the fly. Fully document network architecture, approach used to securely and uniquely identify, authenticate and authorize IoT devices, identify any standards or proprietary technologies used, identify any dependencies, and provide instructions for installation, configuration, management and demonstration.

PHASE III DUAL USE APPLICATIONS: The Phase III effort will focus on commercialization of the technology, which could include use by commercial applications such as wireless sensor & access networks, asset tracking in manufacturing, interactive teller machines, mobile banks, wearables etc. This will entail maturing the Proof of Concept (PoC) Network Access Control for IoT devices designed in phase I from a performance, cost, usability & ruggedization perspective.

Phase III will produce a simple, secure, scalable, automated, and standards-based access control system that allows IoT devices to be uniquely identified, authenticated and authorized access to Army and DoD networks. This solution will mature the Proof of Concept (PoC) design/breadboard developed and demonstrated in Phase II. A Network Access Control (NAC) system for the numerous IoT devices/sensors on the tactical networks will ensure a secure Battlefield of IoT and reduce the enormous cyber vulnerabilities that unauthorized and insecure devices connected to defense networks bring. A dynamic, decentralized NAC for IoT System will not only secure defense networks but reduce/eliminate cost, manpower & lifecycle processes and burden that come with traditional methods of identifying and validating devices on government networks.

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https://nvlpubs.nist.gov/nistpubs/ir/2020/NIST.IR.8259A.pdf;
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5. Internet of Battlefield Things https://www.arl.army.mil/business/collaborative-alliances/current-cras/iobt-cra/

KEYWORDS: Identification, Authentication, Authorization, Network Access Control, secure, unique, Internet of Things (IoT)

VERSION 2

A21-110 TITLE: Advanced Remote Military Yoke (ARMY) – Hub Advanced Payload System (HAPS)

OUSD (R&E) MODERNIZATION PRIORITY: Space, Network Command, Control and Communications

TECHNOLOGY AREA(S): Information Systems, Space Platform

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OBJECTIVE: Develop a means for a small satellite yoke to co-host a small communications hub controller that enables new radio waveforms. Provide receive-store & forward, and direct transmit-receive frequency translation system to be co-hosted on multiple Geosynchronous Earth Orbit (GEO) platforms operating in the UHF and L frequency bands. Develop applications to support payload employment by strategic and tactical users.

DESCRIPTION: Multiple tactical users have various waveform requirements. Mobile User Objective System (MUOS) is now operational. Advanced waveforms beyond MUOS waveform have been created since the initial fielding of MUOS in 2012. Additional MUOS payloads are now on the roadmap. The opportunity to expand MUOS constellation adaptability is now. Additional waveform capabilities risks can be greatly reduced by developing payloads in advance to interface with the follow-on MUOS GEO platform. Additionally required is the capacity to receive multiple 256Kb streams of up to 1 MB File Transfer Protocol (FTP) into temporary digital storage. Each shall have a programmable Time-To-Live (TTL) before crypto-keyed commanded release for transmit or deletion. Additionally, direct translation for low power density waveforms, allowing a full-on transmit & receive functionality in both UHF and L bands, will enable live communications in real-time and serve as an overflow for overloaded capacities and alternative payloads.

PHASE I: Generate and deliver a hub design that enables thousands of Ultra-High Frequency (UHF) satellite communications (SATCOM) users the ability to transmit non-conflicting Right Hand Circular Polarization (RHCP) and receive non-conflicting MUOS RHCP at 225 MHz to 450 MHz and for L-Band SATCOM users the ability to transmit RHCP and receive RHCP at 950 MHz to 2100 MHz. The Hub design must include the configuration capability via S-band. The design must also incorporate the ability for multiple users, using 256Kbps streams, to store up to 1 MB encrypted files with programmatically specified TTL for scheduled release or deletion. The design must utilize the existing capabilities on an existing bus such as the MUOS and be scalable in capability.

PHASE II: Demonstrate and deliver a communications hub prototype meeting the approved Phase I design that is certifiable for space deployment and meeting space flight requirements.

PHASE III DUAL USE APPLICATIONS: Provide a scalable, payload standards-based interface communications hub that enables user's rapid access to prototyping space-based communications payloads to support commercial industries and the DoD.

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REFERENCES:
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KEYWORDS: Tactical Radio, Payload, Store & Forward, Controller, Hub, Access, Satellite, UHF, Telemetry, MUOS, Control, Direct Sequence Spread, GEO

VERSION 2

A21-111 TITLE: MOBILE OPERATIONS UNIFIED SYSTEM EXTENSION (MOUSE)

OUSD (R&E) MODERNIZATION PRIORITY: Network Command, Control and Communications

TECHNOLOGY AREA(S): Information Systems, Electronics

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OBJECTIVE: CREATE MUOS RADIO 5G BRIDGE EXTENSION

DESCRIPTION: The need for expanding communications to meet increasing data requirements continues. Operation in open and closed military environments, and commercially enabled environments requires maximization of bandwidth efficiency to meet new challenges. The US Army, in conjunction with the Mobile User Objective System (MUOS) program, is interested in acquiring a communications hub controller for broadening tactical radio capabilities within the current MUOS satellite constellation. In addition to this capability, the interests are furthered in respect to follow-on MUOS satellite builds. In operating parallel to the existing MUOS communications hub controller, a new communications hub controller must be developed under this effort to perform signal processing to access, host and power correct Radio Frequency (RF) signals as needed for non MUOS waveforms. As with most network hub receivers, multiple remotes must be handled by a network controller. All remote terminals using Division Multiple Access (DMA) are associated with at least four different time windows. Time Division Multiple Access (TDMA) time windows must include guard time, transmission connect time, transmit duration time, and termination time. In a Code DMA (CMDA) the time windows are not as paramount, but still require innovative design to provide this capability, while not interfering with the current MUOS communications hub controller. It is crucial that each remote user, upon access of the communications hub controller, is de-conflicted with the MUOS network. The de-confliction will only be required when the MUOS waveform is present. The communications hub controller will interface to the existing architecture via RF at the frequency range of L-band. The data will interface with a secure network that requires standard Ethernet data interface packets. The requirement of this effort is to design and build a scalable communications hub controller to handle multiple Multi Product UHF L-band System Extension (MPULSE) Quadrature Phase Shift Keying (QPSK) waveform radio accesses that are deploying Direct Sequence Spread Spreading (DSSS) for broad use. MOUSE design must allow additional PSK waveforms to be incorporated later with minimum adjustments required.

PHASE I: The work to be done in Phase I is to deliver a design document. The design document should include the strategy, proposed hardware elements, such as Field Programmable Gate Array (FPGA) components, high-speed multi-FPGA backplane and the standards utilized in accomplishing the tasks to create the communications hub controller. It is significant to note that expectations of accessing thousands of users simultaneously will require a significant amount of parallel processing.

PHASE II: The work to be done in Phase II includes the delivery of the communications hub controller prototype based on the designed developed in Phase I with windows-based management software and standard user documentation.

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PHASE III DUAL USE APPLICATIONS: Success in building the MOUSE controller will prove value to other military and commercial architectures that are upgrading spectrum efficiencies, especially those particular to de-conflicting pre-existing legacy waveforms. A phase III strategy should include the means to develop and market to commercial and military entities.

REFERENCES:

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3. MEDINA, Mobile User Objective System (MUOS) to legacy UHF Gateway Component(MLGC)", 2010, https://ieeexplore.ieee.org/document/5680271;
4. OKRAH, "Channel and interference mitigation in the MUOS base-to-user link", 2008, https://ieeexplore.ieee.org/document/4753492

KEYWORDS: Hub, Satellite, Control, Controller, Direct Sequence Spread, MUOS, Tactical Radio, GEO

VERSION 2

A21-112 TITLE: Small Form Factor Hardware Standards

OUSD (R&E) MODERNIZATION PRIORITY: Control and Communications

TECHNOLOGY AREA(S): Sensors, Electronics

OBJECTIVE: Define and demonstrate small form factor hardware standards that allow modularity smaller than 3U OpenVPX.

DESCRIPTION: Command, Control, Communications, Computers, and Cyber (C5ISR)/Electronic Warfare (EW) Modular Open Suite of Standards (CMOSS), Sensor Open Systems Architecture (SOSA), and Hardware Open Systems Technology (HOST) hardware form factors leverage 3U and 6U OpenVPX to define hardware standards for military C5ISR systems. These standards allow multiple vendors to provide payload modules for C5ISR systems without the need to build to proprietary interfaces or replace entire systems. This increases competition and reduces the cost and effort required to upgrade C5ISR systems. While OpenVPX is suitable for many military ground and airborne platforms, it is not designed for small size, weight, and power (SWaP) platforms such as small unmanned aerial and ground vehicles. To address this gap and provide the benefits of CMOSS to more military programs, this effort will develop initial prototypes implementing open small form factor hardware specifications. As CMOSS, SOSA, and HOST leverage OpenVPX to define hardware standards, the proposed small form factor hardware specifications may leverage existing standards.

Additional requirements for small form factor hardware standards:
- Modularity is smaller than 3U VPX, with modules roughly MXM size (~ 80x80mm surface area)
- Ethernet and PCIe connectivity
- RF connectivity similar to VITA 67
- Optical connectivity similar to VITA 66
- Operates from -40°C to 85°C at cooling surface
- Provide modularity similar to CMOSS standards [i.e. modularity between vendor payloads in a chassis (or equivalent) without modifications to the backplane (or equivalent)]

The initial prototype should include a cooling solution, processing and transceiver modules, an Ethernet switch, and shared position, navigation and timing. Switch and PNT capabilities may be module-based or built into the chassis (or equivalent). Specific prototype performance requirements are not defined.
The initial prototype shall be tested in a relevant environment to validate the specifications. These validation efforts will support further development of the specifications to mature them for transition to CMOSS.

This effort will also develop verification requirements for the small form factor hardware specifications. These requirements will define the verification methodology to be used to test hardware for conformance to each specification requirement. In addition, this effort will design and develop a conformance test kit to automate conformance testing to the greatest extent possible.

PHASE I: Develop an understanding of the key technical challenges that exist to support this concept. Conduct trade off studies on the use of existing small form factor hardware standards. Deliver initial open small form factor hardware standards. Provide an analysis of any performance limitations due to the hardware form factor.

PHASE II: Design and develop prototype using the developed standards with a cooling solution, processing and transceiver modules, an Ethernet switch, and shared position, navigation and timing.

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Demonstrate the hardware with a relevant representative environment. Develop updated small form factor hardware standards for transition to existing relevant standards body. Develop an initial standards conformance plan and test kit for the small form factor hardware.

PHASE III DUAL USE APPLICATIONS: Transition small form factor standards to existing standards body. Develop a payload for small SWaP platforms such as small unmanned aerial vehicles. Provide conformance testing and conformance test kits for small form factor hardware developers.

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KEYWORDS: C5ISR/EW Modular Open Suite of Standards (CMOSS), Sensor Open Systems Architecture (SOSA), Hardware Open Systems Technologies (HOST), Modular Open Systems Approach (MOSA)

VERSION 2

A21-113 TITLE: Ionization Sources for Direct Real-Time Trace Vapor and Aerosol Characterization in Conjunction with a Man-Portable Mass Spectrometer

OUSD (R&E) MODERNIZATION PRIORITY: Biotechnology

TECHNOLOGY AREA(S): Chem Bio Defense

OBJECTIVE: To develop an atmospheric sampler and ion source for attachment to a mass spectrometer. The portable sampler will efficiently ionize atmospheric threats that are biological and chemical in nature.

DESCRIPTION: It is vital to continue the development of a small compact mass spectrometer equipped with an ion source which could be employed for use in chemical and biological defense (CBD) for the direct analysis of vapor and aerosols in near real time. The main goal is to develop an 'air-breathing' ionization source for an existing and ideally commercially available portable instrument. Portable instruments should be compact (<2.5ft3), under <60 lbs, and able to run on batteries and/or 120V AC. The current state of the art largely involves the use of some form of pre-concentration, akin to sorbent tubes, which is then desorbed by flash heating or using a solvent system thereby introducing the sample into the mass spectrometer for analysis and identification. Although pre-concentration strategies are not excluded from this topic, proposers should keep in mind that analysis should be as close to near real-time as possible (e.g. <10 secs). There are a large number of ionization strategies that could be utilized with an 'air-breathing' source; however, proposed efforts should be beyond a basic research effort. Designs that require frequent human intervention are not desired.

The goal of this work is to detect volatile organic chemistry (VOCs) that could be linked to the production of harmful threat material such as toxic industrial chemicals (TICS), energetics, chemical warfare agents (CWAs), and pharmaceutical-based agents (PBAs). Careful consideration should be taken to ensure that confounding chemistry (<75Da) does not significant interfere with the analysis process. Tackling this hurdle requires addressing limitations with both the mass analyzer and the ionization technique. These strategies should be clearly addressed in the proposal.

Proposals which can also be used for biodetection (bacteria, virus or toxin) or address how the system may be modified for these applications are highly desirable.

PHASE I: Conduct feasibility studies of different proposed approaches including modelling, simulation, and calculation of collection and ionization components. Further, consider optimization of the components and subsystems, including fluid dynamics of air intakes for efficient aerosol and vapor collection. The source should allow an instrument that can quickly detect, identify, and quantitate a large variety of chemical/biological species with high accuracy, selectivity, and sensitivity to trace amounts of analyte in complex vapor, and/or aerosol forms in situ is of increasing interest. The instrument response should ideally be within seconds (i.e., in real- time) of exposure to the analyte. The signal of interest should be distinguishable from complex chemical backgrounds (e.g., atmosphere air sampling, vehicle exhaust, smoke, and out-gassing materials) and detectable under varying environmental conditions (e.g., rural/urban settings, range of humidity, and temperature fluctuations).

In preparation for Phase II, 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 II: Investigate use of concentrators and other venturi effects to reduce background signal further. Perform two optimizations: (1) towards targets 250 m/z and below, (2) towards targets 250 m/z to high end mass range of instrument. This will allow for specific deployments to be utilized. Investigate split flow, ion funnels, and other means of efficient ion transmission to preserve ions as pressure is reduced. 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 system. Expand applications to other commercial detectors.

Transfer fully-functional prototype to CCDC CBC for independent verification. 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.

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KEYWORDS: atmospheric sampler, environmental, ionization source, tandem mass spectrometry

VERSION 2

A21-114 TITLE: Novel Processor Architectures for Probabilistic Computing in Survivability Controllers

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence/Machine Learning

TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: Identify novel processor architectures as alternatives to the traditional Von Neumann/Harvard/modified Harvard architecture processors for probabilistic computing and develop a low-cost computing platform utilizing probabilistic processor architectures suitable for the Space, Weight and Power (SWaP) and environment constraints of the Army ground vehicle fleet.

DESCRIPTION: Future military ground vehicles, especially those with active defense and survivability components, will have increased automation requiring more and more computing capacity to distill incoming sensor data and rapidly make autonomous decisions in real-time. While traditional processor architectures are very well suited for deterministically processing relatively small data sets in real-time, as the size of the data sets grows, scaling of traditional processors within the constraints of the ground platform SWaP, environment, and cost targets becomes infeasible. The goal of this project is to identify and examine alternative candidate computing solutions for probabilistic data processing and decision making that would be cost-effective and scalable to the growing processing needs of the Army's ground vehicle fleet.

PHASE I: Phase I entails a feasibility study, concept development, theoretical performance analysis, risk analysis, cost analysis and concept design of a probabilistic processor computing platform. The study shall identify candidate processor architecture solutions, describe the pros and cons of each processor architecture, and provide a recommendation for processor selection for the next Phase. The performance analysis shall describe the theoretical worst- and best-case computational throughput and latency for a range of likely scenarios. The risk and cost analysis shall present multiple options that may reduce risk or cost or provide additional capabilities or performance. The concept design shall provide a detailed technical description of how the recommended processor technology can be integrated into a test bed for performance evaluation.

Expected Deliverables:
1) Analytical report (performance, risk, cost) with conclusions and recommendations
2) Design concept report for the recommended solution

PHASE II: Phase II of this effort shall focus on developing a prototype test bed based on the technology described in Phase I with various risk and cost options selected in consultation with the government POC. The contractor shall develop a prototype test bed to assess the actual performance of the selected processor solution under a range of likely scenarios and computational loads as compared to the theoretical performance documented in Phase I. The causes of any discrepancies between actual and theoretical performance shall be determined and possible solutions shall be identified.

Expected Deliverables:
1) Prototype hardware and software
2) Technical Data Package (includes hardware designs, drawings, schematics; software source code and documentation)
3) Test Report

PHASE III DUAL USE APPLICATIONS: In the final Phase of the project, the contractor shall mature the test bed developed in Phase II, into a final product form factor (embedded processor card, board, or box) and integrate and test the solution with other devices in a vehicle platform and demonstrate a path to commercialization. A solution that has wide appeal and relevance to other fields is preferred. The proposed processor computing platform solution will have applicability to facilitate intelligent decision making for survivability, lethality, and mobility missions for ground vehicle platforms in military applications. The commercial utility of this technology applies to autonomous driving assistance capabilities in consumer and commercial vehicle fleets.

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5. Intelligence Processing Unit https://www.graphcore.ai/products/ipu

KEYWORDS: Novel processor, computer architecture, probabilistic computing, neuromorphic, artificial intelligence, machine learning

VERSION 2

A21-115 TITLE: Vehicle Cybersecurity, Hacking, and Electronic Control Unit (ECU) Simulator

OUSD (R&E) MODERNIZATION PRIORITY: Cybersecurity

TECHNOLOGY AREA(S): Ground Sea, Information Systems, Electronics, Sensors

OBJECTIVE: Develop physics-based modeling and simulation of vehicle components and electronics, including virtual emulation of controllers and other devices, for conducting cybersecurity assessments and vulnerability research.

DESCRIPTION: In order to mitigate the risk of cybersecurity incidents and their likelihood of occurring it is important to continually perform cybersecurity assessments and vulnerability research on Army vehicles. One objective in performing these kinds of cybersecurity evaluations is searching for vulnerabilities in both hardware and software, as they can significantly impact a vehicle system's cyber resiliency (i.e. the ability to withstand a cyber-attack and recover). However, the tools, techniques, and technologies currently utilized in performing these tasks are insufficient and generate substantial risks, costs, and schedule impacts. Many of the issues related to these testing methods can be attributed to their reliance on physical hardware. Accordingly, a solution that develops vehicle cybersecurity simulation technologies will reduce many of the hardware dependencies seen in evaluating a vehicle system during all phases of its lifecycle. Advanced cybersecurity simulators will also have the added benefit of reducing barriers to entry such as high starting costs and the degree of expertise needed for conducting evaluations. To currently minimize hardware dependency, cybersecurity researchers and engineers are able to evaluate systems by utilizing Hardware-in-the-Loop (HIL) and Software-in-the-Loop (SIL) simulators before performing evaluations on physical vehicles. These simulators are capable of emulating hardware and software components, but have their own drawbacks that can diminish their effectiveness in minimizing hardware dependency. For instance, SIL simulators are designed to run code on simulated hardware representations, based on high-level hardware functions. As such, they are ineffective in simulating hardware and may not provide completely accurate results in software simulations. HIL simulators on the other hand validate the performance and functionality of controllers and other electronic devices, but don't provide many capabilities in performing cybersecurity evaluations. Although HIL simulators emulate simple electronics such as sensors and actuators, they generally do not emulate more complex ones and instead require a physical component to interface with. These drawbacks require extensive evaluations to be performed on physical hardware instead.

Many evaluations can be performed in a lab environment using a hardware workstation. This workstation is typically referred to as a test bench setup and incorporates all of the connectors, controllers, and other electronic devices from a vehicle platform. Evidently, this method also has drawbacks with cost and schedule burdens. Firstly, setups lack flexibility, requiring that each platform variant or vehicle model have its own uniquely tailored test bench. Their cumbersome size and lack of portability alone creates logistical burdens in acquiring, transporting, and storing existing setups. All of these issues are reflected in cost and schedule impacts and can multiply for each piece of hardware if there's a need to build a setup from the ground up.

To address the capability gaps in performing cybersecurity assessments and vulnerability research, advanced simulation technologies would primarily need to be able to: emulate any and all kinds of controllers or other electronic devices with physics-based modeling and simulation, even down at the component level (e.g. transistors, resistors, capacitors, etc.), and conduct cybersecurity testing for exploits and vulnerabilities to provide additional utility to cybersecurity researchers and engineers. Notably, simulation tools and illustrative visuals can enable non-cybersecurity professionals to better understand cyber resiliency and critical vulnerabilities throughout a component's lifecycle, promoting more secure and safer vehicles for both the automotive industry and the Army.

PHASE I: Determine technical feasibility for a software-based solution to simultaneously emulate many vehicle ECUs and other electronics devices of varying complexity (e.g. number of transistors, I/Os, and registers, size of memory, dimensions, etc.). Additionally, the solution should outline the capability of emulating software and firmware for these virtualized controllers and devices. Hardware will be virtualized using physics-based modeling and simulation in order to enable the capability of testing for cyber-attacks that utilize the electromagnetic spectrum and other electrical properties, likely drawing on concepts from electromagnetic simulation technology. Inherently, functionality testing evaluates that a system does what it should while cybersecurity testing evaluates that a system does not do more than it should. This is an important consideration for minimizing the attack surfaces of vehicle systems. As such, the solution should also have the inherent capability of testing for known and unknown functionalities in simulated systems.

Design a concept for the solution with open architecture or open-source principles in mind. This flexibility will enable 3rd-party developed systems and components to be seamlessly integrated into the simulator to facilitate and improve various cybersecurity evaluations. Possible use cases include: cybersecurity researchers and engineers uploading tools and reproducible cyber-attacks for conducting cybersecurity assessments and vulnerability research, and Original Equipment Manufacturers (OEMs) uploading their own proprietary controllers and devices in order to conduct cybersecurity evaluations throughout the product development lifecycle. The solution will also outline a common test architecture for integrating known attack scenarios, exploits, and vulnerability scans into the simulator. A common test architecture will improve turnaround times when evaluating system cyber-resiliency against newly discovered vulnerabilities and exploits.

PHASE II: Develop the solution to achieve the capabilities outlined in Phase I. Demonstrate that the solution meets the first major milestone of emulating a target ECU, such as a MIL-PRF-32565 Li-ion 6T Battery Management System, and validate the performance against a HIL simulator using the physical ECU. Demonstrate that the solution meets the second major milestone of simulating all hardware-based and software-based systems for a target military platform, such as the Stryker or Joint Light Tactical Vehicle (JLTV).

Develop a default library of prevalent hacks, exploits, and cyber-attacks for the simulator. Due to some attacks occurring over a long period of time, the solution must also be capable of simulating systems at different points in time. Many different kinds of cybersecurity evaluations can be performed during a session simulating vehicle systems. The results of a session should be recorded or inserted in a report produced by the simulator to easily document or share the findings of cybersecurity evaluations. Sessions should provide metrics on the cyber resiliency of evaluated systems, the details of any vulnerabilities and their severity, the consequences of exploits, and other system information. The solution will demonstrate the capability of generating physics-based models of controllers and devices from preexisting files and schematics such as transistor diagrams and CAD drawings. An intuitive method of generating models for simulation is necessary for efficiently reevaluating systems after design modifications are made to improve functionality or mitigate existing vulnerabilities. These capabilities will also support the efforts of engineers and developers in evaluating their systems without extensive backgrounds in cybersecurity. Deliverables should include a prototype of the software-based solution and source-code, simulator tools for fuzzing, glitching, and reproducible cyber-attacks, and reports and demonstrations assessing the full capabilities of the solution.

PHASE III DUAL USE APPLICATIONS: Expand the capabilities of the solution to simulate different environments and conditions to better reflect the operating environments of Army vehicles. The solution should ultimately be able to conduct cybersecurity evaluations against side-channel and sensor attacks, normally only possible to conduct on physical hardware due to the intricacies and physical properties involved in electronics and the electromagnetic spectrum. For instance, a side-channel attack is designed to pull critical data from electronics through the analysis of hardware power consumption or leaked electromagnetic waves. Physics-based modeling and simulation is necessary in order to emulate these attack scenarios and ultimately reduce hardware dependency for conducting cybersecurity evaluations. Through a combination of sophisticated algorithms and automation, tests could be conducted simultaneously on any number of components, including ports, connections, wires, chips, and devices. Generally, this task is made difficult for even a team of evaluators to perform due to the amount of factors at hand. This simulator would also need to be able to provide developers and engineers, who aren't versed in cybersecurity, the means to evaluate their software and hardware designs against ever expanding libraries of prefabricated cyber-attacks. User training and instructions should be developed to properly utilize this vehicle cybersecurity simulation software. These capabilities would promote the creation of more cyber-resilient systems throughout automotive and defense industries. Automotive companies could easily integrate this simulation technology into their processes for determining the cyber resiliency of their systems. Since tacking on cybersecurity measures becomes more expensive later on in the product development lifecycle, automotive companies could go as far as to require that their suppliers also utilize this solution to perform cybersecurity evaluations early on in development. Likewise, Army components such as Project Managers (PMs) can also implement similar requirements for defense contractors. Due to the flexibility of the solution, similar applications will be displayed in other fields with cyber-physical systems such as in aerospace and industrial control systems.

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KEYWORDS: HARDWARE IN THE LOOP, BUS NETWORKS, GROUND VEHICLES, CYBERATTACKS, CYBER-PHYSICAL SYSTEMS, CYBERSECURITY, VULNERABILITY SCANNERS, COMPUTER SIMULATIONS, ELECTROMAGNETIC FIELDS, ELECTRONICS