ARMY
19.2 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://sbir.defensebusiness.org/. Specific questions pertaining to the Army SBIR Program should be submitted to:

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

The Army participates in three DoD SBIR BAAs each year. Proposals not conforming to the terms of this BAA will not be considered. Only Government personnel will evaluate proposals with the exception of technical personnel from Cherokee Nation Technology Solutions and Georgia Tech Research Institute who will provide Advisory and Assistance Services to the Army and technical analysis in the evaluation of proposals submitted against Army topic numbers:

- A19-124 “A point-of-care assay to determine soldier dengue exposure and enable rapid, mass, cost-efficient dengue vaccination programs of military personnel” (Cherokee Nation Technology Solutions)
- A19-131“Reduced emission sensors for Short Range Air Defense (SHORAD)” (Georgia Tech Research Institute)

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

PHASE I PROPOSAL SUBMISSION

SBIR Phase I proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. **Please note that the Army will not be accepting a Volume Five (Supporting Documents), nor a Volume Six (Fraud, Waste and Abuse) as noted at the DoD SBIR website.** The Technical Volume .pdf document has a 20-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any other attachments. Small businesses submitting a Phase I Proposal must use the DoD SBIR electronic proposal submission system (https://sbir.defensebusiness.org/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheet, the Company Commercialization Report, 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 1-800-348-0787.

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

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

Only the electronically generated Cover Sheets, Cost Volume and Company Commercialization Report (CCR) are excluded from the 20-page limit. The CCR is generated by the proposal submission website, based on information provided by you through the Company Commercialization Report tool. **Army Phase I proposals submitted containing a Technical Volume .pdf document containing over 20 pages will be deemed NON-COMPLIANT and will not be evaluated. It is the responsibility of the Small Business to ensure that once the proposal is submitted and uploaded into the system that the technical volume .pdf document complies with the 20 page limit.**

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

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

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 (**$167,500 maximum-PLEASE NOTE THAT THE MAXIMUM DOLLAR AMOUNT HAS BEEN INCREASED COMPARED TO PREVIOUS PHASE I's**) 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 (**PLEASE NOTE THESE DOLLAR AMOUNTS HAVE BEEN INCREASED COMPARED TO PREVIOUS PHASE I's**). 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

Commencing with Phase II's resulting from a 13.1 Phase I, invitations are no longer required. Small businesses submitting a Phase II Proposal must use the DoD SBIR electronic proposal submission system (https://sbir.defensebusiness.org/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheet, the Company Commercialization Report, the Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DoD Help Desk at 1-800-348-0787.

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

The four Phase II submission cycles following the announcement of selections for the 19.2 BAA are:

2020(b) 2 Mar – 1 Apr 2020
2020(c) 15 Jun – 15 Jul 2020
2020(d) 3 Aug - 4 Sep 2020
2021(a) 15 Oct – 15 Nov 2020

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

SUBMISSION CYCLES	TIMEFRAME
Cycle One	30 calendar days starting on or about 15 October*
Cycle Two	30 calendar days starting on or about 1 March*
Cycle Three	30 calendar days starting on or about 15 June*
Cycle Four	30 calendar days starting on or about 1 August*

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

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

Only the electronically generated Cover Sheet, Cost Volume and Company Commercialization Report (CCR) are excluded from the 38-page Technical Volume. The CCR is generated by the proposal submission website, based on information provided by you through the Company Commercialization Report tool.

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

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 (PLEASE NOTE THAT THIS DOLLAR AMOUNT HAS BEEN INCREASED COMPARED TO PREVIOUS PHASE II's)**. During contract negotiation, the contracting officer may require a Cost Volume for year one and year two. The proposal cost volumes must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Volume Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. Phase II projects will be evaluated after the first year prior to extending funding for the second year.

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

DoD is not obligated to make any awards under Phase I, II, or III. For specifics regarding the evaluation and award of Phase I or II contracts, please read the DoD Program BAA very carefully. Phase II proposals will be reviewed for overall merit based upon the criteria in Section 8.0 of the BAA.

<u>BIO HAZARD MATERIAL AND RESEARCH INVOLVING ANIMAL OR HUMAN SUBJECTS</u>

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 receive an award will be required to deliver CMRA reporting, i.e. if the proposal is selected and an award is made, the contract will include a deliverable for CMRA.

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

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

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

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

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

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

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

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

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

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

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

For more information go to: https://www.armysbir.army.mil, then click the "SBIR" tab, and then click on Transition Assistance/Technical Assistance.

As noted in Section 4.22 of the DoD Program BAA, firms may request technical assistance from sources other than those provided by the Army. All such requests must be made in accordance with the instructions in Section 4.22. It should also be noted that if approved for discretionary technical and business assistance from an outside source, the firm will not be eligible for the Army's Technical Assistance Advocate support. All details of the TABA agency and what services they will provide must be listed in the technical proposal under "consultants". The request for TABA must include details on what qualifies the TABA firm to provide the services that you are requesting, the firm name, a point of contact for the firm, and a web site for the firm. List all services that the firm will provide and why they are uniquely qualified to provide these services. The award of TABA funds is not automatic and must be approved by the Army SBIR Program Manager. The maximum TABA dollar amount that can be requested in a Phase I Army SBIR proposal is $5,000. The maximum TABA dollar amount that can be requested in a Phase II Army SBIR proposal is $5,000 per year (for a total of $10,000 for two years).

COMMERCIALIZATION READINESS PROGRAM (CRP)

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

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

NON-PROPRIETARY SUMMARY REPORTS

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

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

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

ARMY SBIR PROGRAM COORDINATORS (PCs) and Army SBIR 19.2 Topic Index

Participating Organizations	Program Coordinator	Phone
Armaments Center (ARDEC)	Benjamin Call Sheila Speroni	973-724-6275 973-724-6935
Aviation and Missile Center (AMRDEC-A)	Linda Taylor	256-876-2883
Army Research Laboratory (ARL)	Francis Rush Nicole Fox	301-394-4961 919-549-4395
C5ISR Center (CERDEC)	Argiro Kougianos	443-861-7687
Medical Research and Materiel Command (MRMC)	James Myers Amanda Cecil	301-619-7377 301-619-7296
Armaments & Ammunition (PEO AMMO)	Vincent Matrisciano	973-724-2765
PEO Command, Control and Communications Tactical (PEO C3T)	Meisi Amaral	443-395-6725
PEO Ground Combat Systems (PEO GCS)	Lynne Krogsrud	586-215-9072
PEO Intelligence, Electronic Warfare & Sensors (PEO IEW&S)	Michael Voit	443-861-7851
PEO Missiles and Space (PEO M&S)	David Tritt	256-313-3431
PEO Soldier	Mary Harwood	703-704-0211
Ground Vehicle Systems (TARDEC)	George Pappageorge	586-282-7541

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.

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

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

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

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

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

4. SBIR Phase I Proposals have four (4) sections: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume .pdf document has a 20-page limit including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents [e.g., statements of work and resumes] and all attachments). However, offerors are instructed to NOT leave blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal submission as THESE WILL COUNT AGAINST THE 20-PAGE LIMIT. Any information that details work involved that should be in the technical volume but is inserted into other sections of the proposal will count against the page count. ONLY the electronically generated Cover Sheet, Cost Volume and Company Commercialization Report (CCR) are excluded from the Technical Volume .pdf 20-page limit. As instructed in Section 5.4.e of the DoD Program BAA, the CCR is generated by the submission website, based on information provided by you through the "Company Commercialization Report" tool. Army Phase I proposals submitted with a Technical Volume .pdf document of over 20-pages will be deemed NON-COMPLIANT and will not be evaluated.

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

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

7. If applicable, the Bio Hazard Material level has been identified in the Technical Volume.

8. If applicable, plan for research involving animal or human subjects, or requiring access to government resources of any kind.

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

10. If applicable, Foreign Nationals are to be identified in the proposal.

ARMY SBIR 19.2 Topic Index

A19-102	Effect of Heat Treatment on Additively Manufactured Ti-6Al-4V Alloy
A19-103	High assurance hardware state machine trusted computing base
A19-104	Cryogenic Production for Airborne Thermal Management
A19-105	Innovative Muzzle Brake Design for Artillery
A19-106	Collaborative Fire Control Decision Aids
A19-107	Carbon Fiber Thermoplastics with High Through Thickness Modulus
A19-108	Conformal RF Interfaces for Gun-fired Munitions
A19-109	Maximizing Persistent Coverage of a Predetermined Area of Interest by Swarms of Assets for Targets Acquisition and Engagement
A19-110	Multifunctional Materials for Increased Lethality Munitions
A19-111	Non-Destructive Inspection of Modern Explosives and Ammunition Housings
A19-112	Optical Based Proximity Sensor for Fuzing
A19-113	Alternative Manufacturing Methods and Materials for Gun-Launched Components
A19-114	High Sensitivity Miniaturized Gun-hardened Aeroballistic and Geolocation Sensor Technology
A19-115	Synthetic Aperture by Direct Print-down of Micro-lens Arrays on CMOS Imagers
A19-116	Integrated 2-color thermal polarimetric sensor and deep neural network system for artificial intelligence and machine learning (AI&ML) based automatic target detection and identification
A19-117	Advanced, compact acoustic particle velocity-pressure sensory system
A19-118	Image data compilation based on accurate registration of sequential frames from a drone
A19-119	Deep Generative Modeling of Infrared Datasets for Aided Target Recognition
A19-120	Novel Integration Technologies for Infrared Focal Plane Array Application
A19-121	Foveated Headworn Display Demonstrator
A19-122	Variable Attenuator for See-Through Day/Night Displays
A19-123	Advanced Concepts for Low-Cost High-Speed Uncooled Infrared Detectors
A19-124	A point-of-care assay to determine soldier dengue exposure and enable rapid, mass, cost-efficient dengue vaccination programs of military personnel
A19-125	Advanced Machine Learning Target Recognition in Munitions
A19-126	Advanced Machine Learning for Non-Destructive Testing
A19-127	Software Defined Radio Automated Testing Solution
A19-128	Intelligent Manufacturing Technologies for Lithium-ion 6T End-of-Line Testing
A19-129	Advanced Signal Detection and Characterization Utilizing Artificial Intelligence (IL)/Machine Learning (ML)
A19-130	Aerostat Hybrid
A19-131	Reduced emission sensors for Short Range Air Defense (SHORAD)
A19-132	Next Generation Aviation Helmet Shell
A19-133	Power Generation for Individual Soldier
A19-134	Real-time Muzzle Velocity Feedback System (RMVFS)
A19-135	Powder Development and Characterization for Additive Manufacturing of FeMnAlC Alloy Steel
A19-136	2kW Solid Oxide Fuel Cell (SOFC) Power System

ARMY SBIR 19.2 Topic Descriptions

A19-102 TITLE: Effect of Heat Treatment on Additively Manufactured Ti-6Al-4V Alloy

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: The key objective of this work is to evaluate the mechanical properties and microstructural characteristics of post-process heat treatments of Additively Manufactured (AM) Ti-6Al-4V alloy including process-structure-property relationships. Tensile testing, smooth bar high cycle fatigue testing and microstructural analyses are to be performed on Laser Powder Bed Fusion (L-PBF) manufactured near net shape Ti-6Al-4V specimens having four heat treatment types after Hot Isostatic Pressing (HIP). These heat treatments are Mill-Anneal (MA), ANNeal (ANN), Solution Treat and Age (STA) and Beta Solution Treat and Overaged (BSOA). The resulting mechanical properties and microstructures will be compared to the traditional Ti-6Al-4V alloys bars, forgings and castings. The quantitative process-structure-property relationships will be determined with computational modeling with respect to build orientation.

DESCRIPTION: Additive Manufacturing (AM) is a new production technology that enables reduced manufacturing steps, part consolidation and production of near net shape parts from 3-D model data. Current applications mainly focus on secondary structures or other non-critical applications. Recent developments in AM technology and AM Standards offer great potential to implement AM produced part in the US Army. In the past few decades, there is an increasing interest to produce metallic AM parts for structural and non-structural applications, as these materials show acceptable performances compared to the traditional materials with shorter lead times, less material usage and near net-shape parts [1-8]. The use of AM titanium alloy replacement of a currently used traditional titanium alloy in the US Army helicopters with a same traditional alloy heat treatment types may not provide an increased utilization of the AM titanium alloy and may cause additional performance risk since heat treatment for AM titanium alloy is not optimized.

The current standard ASTM F2924 [9] of the AM Ti-6Al-4V alloy mechanical properties in all direction requires minimum tensile properties (130 ksi UTS/120 ksi YS/10% Elong) regardless of heat treatment types and part thicknesses. The thickness of the part affects the grain size of the part during solidification as such the grain sizes are smaller for the small thickness compared to the thick part. Therefore, tensile properties are higher for a part with small grains even though both parts had same heat treatment types. On the other hand, the tensile properties are also depends on heat treatment types. For example, annealing heat treatment provides lower tensile properties compared to the solution heat and aged heat treatment. Therefore, the effects of heat treatment types coupled with part thickness and resulting mechanical properties need to be thoroughly investigated.

In this study, the L-PBF AM process will be used to manufacture near net shape AM Ti-6Al-4V test specimens, and evaluate the effect of post-processing heat treatment types on tensile and fatigue properties, compared to the baseline Ti-6Al-4V alloy bar, forging and casting material properties. To understand the process-structure-property relationships, computational modeling is to be utilized to predict the quantitative mechanical properties such as tensile, yield, elongation and fatigue strength.

The project will be conducted in three phases. Phase I will focus on assessment, design and selection of parameters, computational model, manufacturing options and procurement of AM Ti-6Al-4V alloy powder. Phase II will focus on demonstrating the ability to manufacture near net-shape of tensile and fatigue specimens, perform tensile, fatigue tests and evaluate tensile, fatigue test results of four heat treatment types (MA, ANN, STA and BSTOA) and quantitative prediction of process-structure-property relationships along different directions. Ten tests (10) at room temperature per heat treatment types will be evaluated for both tensile and high cycle fatigue (0.1 R-ratio) tests. Beta transus temperature of the two specimens will be determined for heat treating guidance. The chemical composition and density of each lot will be determined. The chemical composition and physical properties of the Ti-6Al-4V powder will be verified. Only one batch of virgin powder and no recycled powder will be used. A few trial manufacturing is to be made to verify specimen sizes, quality and tensile properties. Phase III will focus introduction of AM Ti-6Al-4V alloy into a broad range of defense and civilian applications. This technology has been demonstrated in a laboratory research scale and prototype parts. The current effort would use existing technology to develop an optimized heat treatment types for AM Ti-6Al-4V alloy process utilizing simple shaped tensile and fatigue specimens. It is noted that the listed references [9-20] are to be used for general guidance on materials, manufacturing, heat treatment, testing and reporting to accomplish the objective of this project. The project's three major phases are described below.

PHASE I: Phase One evaluates the engineering merit and feasibility of the proposed technology. It identifies and builds team with industrial partners, design and select AM Ti-6Al-4V powder type, size and amount of experimental test specimens, AM manufacturing and, assesses application and manufacturing options, addresses producibility and inspectibility using these test specimens, selects predictive computer modeling and investigates the overall benefits of the project. The interrelations among AM processed Ti-6Al-4V alloy heat treating conditions and resulting microstructure parameters (alpha layer thickness, alpha and beta phase content, grain size, density, etc.) and mechanical properties are still not fully understood. To understand the process-structure-property relationships computational modeling need to be utilized to predict the quantitative mechanical properties. The objective of the process-structure-property relationships between the heat-treating conditions and microstructural features is to be able to predict the microstructure and resulting mechanical properties for a given part geometry, size, and feature orientations for a given heat treating conditions. Such a model would be the basis for improving first part yield and enabling rapid part qualification. In order to verify the process-structure-property relationships, experimentally measured microstructural features and tensile properties are required in x, y and z directions. A generic computational model or a modified one to predict properties could be used for predicting process-structure-property relationships. To predict complex part process-structure-property relationships, selected complex shaped parts will be modeled to determine properties. These representative complex shaped parts will be manufactured in Phase II and mechanical properties and microstuctural features will be measured with respect specimen orientations for modeling verification. Recommended computational modeling is to be demonstrated with open source microstructure and mechanical data for the AM Ti-6Al-4V alloy. Further ideas beyond described are welcome. An appropriate process modeling could be used to minimize process defects and maximize the mechanical properties for optimum producibility if needed and funding are available.

Required Phase I deliverables include monthly progress reports, final technical report including specimen sizes, testing specimens locations, tests, powder specification and amount, AM build layout and manufacturing plans, predicted computational model examples demonstrating the process-structure-property relationships including complex shapes.

PHASE II: Phase Two will manufacture the specimens and evaluate tensile and fatigue test results, predictive computational modeling compared to the traditional Ti-6Al-4V alloy bars, forgings and castings. The process will utilize an L-PBF process. The shapes of AM specimens will be simple-shaped L-PBF manufacturing. The overall dimension in length could be 8.0 inches with three wall thickness ranges as 0.25, 0.50, 1.00 and 2.00 inches with appropriate machining stocks. Any required radiuses could be 0.02 inches. All specimens will undergo HIP prior to the following heat treatments: 1) mill-anneal, 2) anneal, 3) solution treated and age and finally 4) beta solution treated and overaged. Tensile, fatigue, hardness, density, optical microscopy, scanning electron microscopy and computer tomography (CT) analyses are to be utilized to generate and analyze the resulting data during the Phase II effort. Ten (10) tests will be performed at room temperature per heat treatment types. Additionally, ten (10) tests will be performed at room temperature as AM manufactured and as HIPed for baseline comparison. Tensile, fatigue, hardness, density, optical microscopy, scanning electron microscopy and computer tomography (CT) analyses are to be utilized to generate and analyze the resulting data during the Phase II tensile evaluation. The specimens will undergo both tensile and high cycle fatigue (0.1 R-ratio) tests. Beta transus temperature of the two specimens as well as the chemical composition of each lot will be determined for heat treating guidance. Additionally, the chemical composition and physical properties of the Ti-6Al-4V powder will also be verified. Only one batch of virgin powder (no recycled powder) will be used, and all specimens will come from the same AM build feedstock. Trial printed specimens will be made to verify specimen sizes, quality and tensile properties. The interrelations among AM processed Ti-6Al-4V alloy heat treating conditions and resulting microstructure parameters (alpha layer thickness, alpha and beta phase content, grain size, density, etc.) and mechanical properties are to be determined. To understand the process-structure-property relationships, computational modeling is to be utilized to predict the quantitative mechanical properties. Such a model would be the basis for improving first part yield and enabling rapid part qualification. In order to verify the model, experimentally measured microstructural features and tensile properties are required in x, y and z directions. The resulting data is to be used to validate the computational modeling.

Required Phase II deliverables include bi-monthly progress reports, test reports, computational predictive mechanical property evaluation and a final technical report including powder chemical and physical properties, AM Ti-6Al-4V chemical analysis, CT and dimensional inspections, tensile, hardness, fatigue testing, microstructure, fractography analysis, computational model inputs to predict properties, verification and example of the model predictions.

PHASE III DUAL USE APPLICATIONS: Phase Three will address the transition path of this technology resulting from Phase II effort to various US Army components with industrial partners and Original Equipment Manufacturers (OEMs).

This technology has been demonstrated in a laboratory research scale and on prototype parts. This program effort would use existing technology to develop an optimized heat treatment process for AM Ti-6Al-4V alloys, quantitative process-structure-property relationships utilizing simple shaped tensile and fatigue specimens. It is noted that the listed references [9-20] are to be used for general guidance on materials, manufacturing, and heat treatment, testing and reporting to accomplish the objective of this project.

The implementation targets are defense applications. The expected benefit of the resulting project data could become a heat treatment guide for AM Ti-6Al-4V alloy components used in US Army applications requiring tensile strength, fatigue strength and combination of both tensile and fatigue strength for performance requirements. The relevant technical data generated and experience gained in this project are expected to positively impact application of additively manufactured titanium components in a broad range of defense applications where light weight and reduced lead time are needed for very complex parts that use titanium components. All these project benefits will result in improved U. S. readiness and capability.

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KEYWORDS: Additive manufacturing, heat treatment, Ti-6Al-4V alloy, tensile properties, microstructure, laser, powder bed fusion, process structure property relationships

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A19-103 TITLE: High assurance hardware state machine trusted computing base

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Cybersecurity systems need to take advantage of high assurance provided by state machines used for aviation and safety critical systems. Offeror shall research a high assurance state machine trusted computing base for a high assurance operating system.

DESCRIPTION: Safety critical systems use state machines to achieve high computer security assurance levels. State machines make security reviews for EAL6 or higher tractable. Current generation aviation systems were not developed with strong computer security requirements. Past cyber threats, [1]-[2], current cyber treats, Spectre [3] and Meltdown [4], and future cyber treats need to be countered.

Embedded system designs are typically based on commodity hardware optimized exclusively for speed – leading to critical cyber vulnerabilities that can have devastating effects on safety and mission effectiveness. This has also led to the unsustainable "Perimeter, Patch, Pray" Information Assurance strategy [5] that is simply impractical for fielded aviation and missile systems.

We are interested in researching a separation kernel-like operating system consisting of a hardware state machine as the trusted computing base and a high assurance operating system. In terms of computer virtualization concepts: the trusted computing base is a hardware state machine and the OS can be compared to a guest operating system.

Recent developments in the open source hardware and software communities have created the open source RISC-V [6] and OpenPiton [7] microprocessors and high assurance open source operating system, seL4 [8]. Open source architectures provide for more thorough security reviews compared to closed source systems [9]. Open source architectures also provide for lower life cycle system cost. We are interested in leveraging the open source communities for this research topic area. Preference will be given for open source hardware and operating system modules.

PHASE I: For the Phase I proposal, offeror shall describe the feasibility of using a hardware and software co-design to create a high assurance state machine as the trusted computing base for a high assurance operating system.

(1) Propose high assurance state machine trusted computing base concept.
(2) Propose an operating system to take advantage of trusted computing base.
(3) Propose a system architecture describing: hardware, microprocessor, state machine, operating system, and application software.
(4) Describe the cybersecurity advantages of (3) over current commodity microprocessors and operating systems.
(5) A plan to achieve a cybersecurity security rating of at least EAL6.
(6) Describe potential Army, medical, and commercial applications; and
(7) Provide a business model to market the proposed system.

For the phase I effort, the offeror shall demonstrate the feasibility and security benefits of creating a high assurance hardware state machine trusted computing base and high assurance OS.

(1) Develop models, simulations, prototypes, etc. to determine technical feasibility of developing a high assurance system
(2) Deliver a System Architecture and Description Report; and
(3) Deliver an EAL Certification Plan Report.

PHASE II: Offeror shall develop a high assurance computer system based on offeror's proposal and phase I effort. It is highly recommended that the offeror team with a government prime contractor. The offeror shall demonstrate high assurance computer system running an Army application (like Joint Multi-Role Technology Demonstrator [19]). The Offer shall propose potential applications for a system demonstration and implement an application with government concurrence.

Offeror shall deliver a year 1 report and a year 2 report describing artifacts, documents, verification tests, etc. completed following the plan in the Phase I document EAL Certification Plan Report. Offeror shall deliver 2 prototype systems to the government point of contact for test and evaluation with all software tools and licenses (if required) to build and use the system. Offeror shall provide 2 days of on-site training for the system.

PHASE III DUAL USE APPLICATIONS: Offeror will develop and market high assurance system based on phase II development work and marketing plan from phase I. Offeror will achieve EAL6 or greater for high assurance computer system. Offeror will integrate high assurance hardware/OS system into an Army Aviation or Missile subsystem currently under development or via technology refresh.

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KEYWORDS: Assurance, cyber resilience, embedded systems, trusted computing, state machine

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A19-104 TITLE: Cryogenic Production for Airborne Thermal Management

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop and demonstrate a practical lightweight system for an on wing cryogenic liquid production system applicable to airborne thermal loads, and suitable for implementation on future US Army rotorcraft.

DESCRIPTION: Emerging aircraft concepts are calling for increased electrical power and in many cases all electric aircraft designs. While accommodating the electric power requirement is a challenge in and of itself, thermal management of the components for the system becomes a priority engineering challenge as well. Cooling technology needs for these aircraft architectures are driven by the power and cooling demands of aircraft components such as superconducting motors/generators, Directed Energy Weapons (DEWs), and high-powered jammers. From a military perspective, high pulse power loads devices, such as DEWs, offer significant opportunities, as well as challenges, compared to traditional kinetic weapons. Airborne DEWs could perform a variety of Army missions including missile defense, counter-UAV operations, suppression of enemy air defenses, precision strike, etc. Although not limited to high energy lasers (HELs), the challenge of integrating such a device into a mission equipment package (MEP) illustrates the technical challenges ahead.

HELs do not consume ammunition in the traditional sense, though they do consume significant amounts of electrical power. Lasers are intrinsically inefficient, and the “wall plug” efficiency can be considerably less than 50%. This means that to fire a 50 kW laser, 100 kW of electrical power would be needed. In addition, the net 50 kW of waste heat that is rejected to fire the laser must also be cooled which requires a cooling device that adds more size, weight, and power (SWaP). Typically the laser itself has tight thermal constraints which limit temperature changes to +/- 1° Celsius. Additionally, operating temperatures of the device are close to the operating temperatures of the external ambient air. The low-quality heat is extremely difficult to move around. Therefore, significant incentive exists to maximize the efficiency of airborne DEWs to minimize both power and thermal management requirements.

One way to enhance the efficiency of a laser is to cool it and operate the laser at cryogenic temperatures. Research has shown that wall-plug efficiency in excess of 70% is possible for cryogenically cooled solid-state lasers using liquid nitrogen (LN2). An airborne DEW operating at this efficiency would have significantly reduced power and thermal management requirements, but these benefits are only possible if the system is cryogenically cooled. For a cryogenic cooling system to be attractive, the benefits of increased efficiency must outweigh the cost, complexity and SWaP penalties associated with its implementation. If successfully developed, a low weight cryogenic liquid generator could be applied to a cooling system for superconducting motor/generators, high powered jammers, and/or HEL type devices.

Metric goals and characteristics for the on-wing cryogenic liquid generator are as follows. The ratio of the amount of liquid cryogen produced per day to the device weight ((liters/day)/kg) should be greater than 1; with higher ratios being consequentially more desirable. For close looped systems assume the system has already been chilled and/or the reservoir is available. Production (cooling capability) goal is greater than or equal to 100 liters/day. Weight of the production equipment should not exceed 250 kg; weight is highly valued on a rotorcraft, hence any that can be removed should be. Operational ceiling is up to 5500 meters; performance must be characterized over the operational range. Temperatures up to 50 Celsius should be considered. If bleed air from an aircraft engine or secondary power unit (SPU) is required in the design, limit the bleed flow to a maximum .45 kg/sec (1 lb. /sec). Electrical power to drive equipment can assume 270VDC and an allotment of up to 40 kW of electrical load. Note, this system is not limited to LN2, innovative concepts which use any low temp fluid will be considered, such as, but not limited to liquefied natural gas (LNG), Ammonia, liquid ethylene, etc.

PHASE I: Develop a design for a cryogenic liquid generator which meets or exceeds the aforementioned specifications. Utilization of models, and a systems engineering perspective is encouraged.

PHASE II: Develop and demonstrate the critical components of the cryogenic liquid generator through prototyping and laboratory component/system testing.

PHASE III DUAL USE APPLICATIONS: Phase III options would include development of a fully-functional prototype that could be used for cryogenic DEW ground and flight testing. For dual us applications the same technology could also be applied for other ground, naval, and airborne thermal management applications such as cooling superconducting systems including high-efficiency, compact motors and generators and lightweight power distribution systems.

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KEYWORDS: Directed energy weapons, auxiliary power unit, thermal management, cryogenic cooling

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A19-105 TITLE: Innovative Muzzle Brake Design for Artillery

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Develop novel muzzle brake structures for extended range cannon artillery systems that reduce mass and manufacturing cost, while maintaining or improving recoil reduction, signature management, durability, and operator safety.

DESCRIPTION: Given the Army's Long-Range Precision Fires priority, a need exists for novel and innovative muzzle brakes capable of supporting the new extended range cannons. These include but are not limited by munitions currently under development for direct and indirect fire missions. High pressure produced at muzzle exit have negative impact upon the surrounding environment due to muzzle blast flow fields exiting the barrel. The negative consequences, such as recoil and noise production, can be alleviated by redirecting propellant gases. Muzzle brakes have been used for decades to efficiently redirect propellant gas, resulting in effective performance gains. However, recent advances in materials and additive manufacturing techniques show promise for muzzle brake weight reduction and manufacturing cost while maintaining the favorable flow field response and resistance to the resulting thermal and pressure loading.

Muzzle brakes are subject to complex loading due to high exit pressure and gas momentum from the projectile emersion from the gun tube. Conditions at muzzle exit are dynamic and vary based on multiple factors. Typical pressure and thermal conditions have been found to be as much as 10-12 ksi and 2000 K, respectively. Gas flow has been found to be as high as 1,500 m/s and may contains small particles, such as solid propellant grains that did not undergo combustion. The muzzle environment can cause erosion on the brake surfaces. The shape of the muzzle brakes often consists of complex three-dimensional curves and multiple openings. Examples of various muzzle brakes over the last century can be found in the references. Due to the harsh environment, material performance requirements, and complex shapes muzzle brakes used in current artillery systems are made of cast/forged steel.

This topic seeks to develop novel applications of advanced materials, coatings and manufacturing technologies to muzzle brakes. A variety of analyses and tests should be done to show that the materials can survive the environment and that the manufacturing process can produce the complex shapes required. The objective for this effort is to achieve 30 percent weight reduction with either comparable or reduced cost compared to conventional steel muzzle brakes.

PHASE I: Evaluate various material and coating combinations for use in the muzzle brake environment. Investigate manufacturing technologies such as additive manufacturing for combination with promising materials and coatings. Reference 1 (AMCP 706-251), section 3-3.2 provides an example of an open muzzle brake that can be used as a baseline. Conduct an analysis of alternatives to select the best combination of materials and manufacturing for prototypes to be delivered in Phase II. Select a candidate shape for Phase II. Reference 4 (US Patent No 8,424,440) for a 105mm gun is the preferred shape but other 105mm or 155mm shapes may be used with TPOC concurrence. Perform a preliminary validation of the manufacturing concept and prepare initial production cost estimates for the designs under consideration.

PHASE II: Subject promising material / coating combinations identified in Phase I to tests that simulate live fire conditions. Perform feasibility trials on the production of the muzzle brake design selected in Phase I. Produce at least one prototype muzzle brake using the selected final material / coating / manufacturing combination. Subject "as manufactured" sections of the prototype to simulated firing conditions to assess as manufactured performance.

Perform final design refinements. Document final material, coating, and manufacturing process.

PHASE III DUAL USE APPLICATIONS: Conduct a live fire demonstration of the final prototype in an operational environment with involvement from the prime contractor for the weapon system. Explore potential small arms applications for both military and private sector customers.

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KEYWORDS: muzzle device, muzzle brake, manufacturing, artillery, cannon

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A19-106 TITLE: Collaborative Fire Control Decision Aids

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Develop a system to aggregate friendly force small arms fire control data to compute and display which individual or team has the highest probability of successfully engaging a target.

DESCRIPTION: This effort supports the Army Modernization Priority of Soldier Lethality.

Smart, networked small arms fire control systems are increasingly commonplace, especially with the proliferation of smartphones. Devices like the Kestrel Weathermeter [1] and the Sig Sauer KILO2400ABS laser rangefinder [2] have the capability to communicate with devices like smartphones to share data on environmental conditions, the weapon itself, and ammunition. These capabilities allow users to quickly create and edit ballistic inputs to maximize effects.

In addition, there are techniques [3] that have been developed to compute the probability of hit for a small arms weapon system based upon the uncertainty in parameters like range to target, muzzle velocity, and wind speed. These techniques allow a user to provide a performance estimate for a weapon system given its ballistic parameters and the user's ability to measure and control the other factors that affect the flight of a bullet.

By developing a method to connect the fire control systems to a centralized probability of hit calculator, this topic seeks to provide unit commanders with the capability to determine which asset at his disposal (e.g. infantry with an M4 or a sniper with an M110 and a laser rangefinder) would best be able to engage a given target. This would not be based only on user-provided information but would tie in actual measurements from sensors like weather meters, laser rangefinders, and weapon-mounted displays. Target/enemy information, such as enemy position and threat type, could be provided to the calculator from any number of sources, e.g., radar or individual user input. This data will provide the most accurate picture of friendly units' ability to engage threats. The integration of this data would enable a commander to evaluate the impact of moving units and threats around on a map, and to evaluate how the firing solutions and P(hit) calculations change, allowing him to determine which unit should engage each target to maximize the probability of successfully neutralizing the enemy.

PHASE I: The objective of Phase I is to develop a system architecture and methodology for aggregating fire control data over a generic network that enables the data to be transferred and shared among systems. Document the proposed solution. Demonstrate software that couples simulated data from multiple sources with target profiles to compute a firing solution and probability of hit for each friendly asset.

PHASE II: Phase II will build on a successful Phase I demonstration to connect physical devices to the probability of hit application and develop a user interface that presents the information on a map. The map should factor local terrain into the firing solution. The application should allow the input of enemy locations from users or from other sources. Demonstrate the capability to concurrently connect over 50 devices to the network and display their computed performance probabilities based upon the entered enemy parameters.

PHASE III DUAL USE APPLICATIONS: This technology can be provided to law enforcement to help in deployment of their units in counter-sniper applications. This capability could be extended to other types of munitions, such as vehicle mounted weapons or indirect fire weapons, to help commanders better plan positioning of the units. There is also the potential for this capability to be used in the commercial market, allowing hunters to determine the best place to set up for engaging targets.

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KEYWORDS: Small arms, fire control, networked, probability of hit, sniper

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A19-107 TITLE: Carbon Fiber Thermoplastics with High Through Thickness Modulus

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Increase the through thickness modulus of carbon fiber thermoplastic composites through the use of nano-additives. These composites are used on large caliber direct and indirect fire gun tubes. They use polyetheretherketone (PEEK) as the thermoplastic matrix and are processed via fiber placement. The increase in the through thickness modulus should not decrease the in-plane properties of the composite nor the ability to process it via fiber placement.

DESCRIPTION: There is a need to increase the through thickness modulus in fiber placed thermoplastic composites. These materials are being used to overwrap gun tubes for both direct and indirect fire and the effectiveness of the composite wrap is limited by the through thickness modulus. Traditionally this modulus is only that of the matrix material which is an order of magnitude or more lower than that of the reinforcement. On previous efforts it was found that after about 0.5 - 0.75 inches of overwrap adding additional material doesn't help with limiting bore dilation due to the low modulus in the radial direction being solely a function of the matrix. This effort focuses on developing a process to increase the through thickness modulus by adding nano-materials to the matrix. The addition of these materials should not be detrimental to the in-plane properties of the base composite and should still be processable via fiber placement.

PHASE I: Develop a process to increase the through thickness modulus of carbon fiber reinforced thermoplastic by adding nano-materials to the system. For this effort the baseline material is the fully unidirectional carbon fiber / polyetheretherketone (PEEK) system commonly referred to as IM7/PEEK. This material is processed via fiber placement using either hot gas torches or lasers as the heating source. The material is processed as a fully consolidated tape of IM7/PEEK. A study should be conducted as to what type / loading amount of nano-material will give the highest increase in through thickness modulus without degrading in plane properties or processability. A suggested method for measuring the through thickness modulus is ASTM D695 with two to one size anisotropy though other methods are acceptable. The threshold is a 75% increase in through thickness modulus over the baseline of pure PEEK. The objective is a 200% increase. The material deliverable is the equivalent of one square meter (can be of any width) of the improved material for testing. The material deliverable does not have to be in a form processable by fiber placement but should be processable by heated platen press or autoclave.

PHASE II: Refine the process and improve the modulus results over Phase I. Minimum expected improvement is 100% over pure PEEK with an objective of 200% or more increase. Material must be processable via fiber placement. The as processed interlaminar shear strength (D2344 -Standard Test Method for Short-Beam Strength of

Polymer Matrix Composite Materials and Their Laminates), shall be equal to or greater than 9 ksi and any deviation from this value shall be reported and a plan to achieve 9 ksi shall be described. No degradation of the in-plane properties shall be verified by conducting at a minimum ASTM D3039 (Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials) in both longitudinal and transverse directions. Thermal conductivity shall also be measured to determine if there is any increase over the baseline material. The material deliverable is 25 lbs of 1/2" wide material capable of being processed via fiber placement.

PHASE III DUAL USE APPLICATIONS: Finalize the development of a material-based solution at production level quantities that can be readily implemented on existing manufacturing equipment. Non-DoD applications include down well piping, engine components, etc.

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KEYWORDS: Advanced Composites, Nanomaterials, fiber placement, thermoplastic composites

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A19-108 TITLE: Conformal RF Interfaces for Gun-fired Munitions

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Investigate and develop innovative solutions to enable integration of electronic warfare antennas on munition launched rounds. Antenna systems must be capable of surviving a typical mortar gun launch and maintaining their operational performance throughout flight.

DESCRIPTION: Recent advancements in high-shock, munition-launched compatible electronics technology particularly have opened up a wide realm of possibilities for enabling long-range and inexpensive electronic warfare attacks of ground targets via relatively inexpensive munition launched systems and projectiles. To enable this mission, projectiles must be equipped the associated electronics and RF sensors. Due to the highly constrained volume and structural integrity requirements, these sensors must be conformal to the outer mold line with very minimal intrusion into the structural wall of the projectile. Surface area on these projectiles is also very limited; therefore, these sensors must be small, residing within the allotted payload space. It is also requisite that the sensor operates over several ISM bands, while providing omni-directional beam pattern coverage. All this must be performed at shock loads approaching 20,000 g’s.

Army is looking for novel advancements in conformal antenna technology to enable this mission set on a range of prospective gun-launched platforms (e.g. mortars and artillery). Aperture designs should be innately scalable to accommodate different munitions with tuneable frequency characteristics and incorporate knowledge and understanding of relevant high-shock compatible materials and construction techniques. A critical aspect of the effort involves that the apertures are insensitive to large changes in response due to the large shock loads experienced during launch. Furthermore, designs should incorporate knowledge and understanding of miniaturization techniques, while still achieving the objective bandwidth and pattern coverage requirements.

PHASE I: During the Phase I contract, successful proposers shall conduct a proof of concept study that focuses on the feasibility of designing the antenna apertures. Investigations should include analysis of potential aperture mounting configurations, achievable antenna performance (gain, bandwidth, pattern coverage), and materials capable of surviving the expected environments. Verification of RF performance shall be accomplished through simulation and prototype antenna measurements. A final proposed concept design, including a detailed description and analysis of both expected thermal and mechanical loads, is expected at the completion of the Phase I effort.

PHASE II: If selected for a Phase II, the proposer shall fabricate and integrate the prototype antenna apertures into a nominal projectile form-factor. The proposer shall further their proof of concept design by performing component shock and thermal testing on critical components/connections of the aperture. Special emphasis on launch survivability will be required, including hard force and electromagnetic effects during testing to ensure the apertures can avoid failure or degradation. Upon evaluation of the design through a critical design review, the prototype hardware’s survivability shall be demonstrated through either air-, chemical-, or munition launches. Information and data collected from the flights will be used to validate operational electrical performance.

PHASE III DUAL USE APPLICATIONS: Phase III selections shall ruggedized final design, fabricate it and integrate the prototype antenna apertures into nominal projectile form-factor to be identified by the Government. Live fire tests will be conducted and the antenna integrated with projectile form-factor will have to withstand shock load approaching 20,000g’s. Phase III selections might have adequate support from an Army prime or industry transition partner identified during earlier phases of the program. The proposer shall work with this partner (TBD) to fully develop, integrate, and test the performance and survivability characteristics of the design for integration onto the vendor’s target platform.

COMMERCIALIZATION: Robust, high-shock antenna components are continually in demand by the aerospace and chemical / petroleum industry. Further commercial applications include civilian space-flight initiatives and application of the antenna technology for the design of low-cost, high-temperature, high-shock antenna sensors.

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KEYWORDS: Antenna, electronic warfare, projectile, munition, mortar, artillery, sensors

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A19-109 TITLE: Maximizing Persistent Coverage of a Predetermined Area of Interest by Swarms of Assets for Targets Acquisition and Engagement

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Design and develop an optimization algorithm to provide persistent coverage of an area of interest by swarms of assets for target acquisition and engagement.

DESCRIPTION: This effort aims to provide a significant capability to the Soldier Lethality CFT by increasing data accuracy during the direct fire engagement process for digital soldiers. This topic will also develop swarming technologies that can be integrated into NGCV for targeting and engagement; specifically by utilizing augmentation of LOS/BLOS NGCV fires and effects integrated with upper-echelon systems for cooperative engagement, as well as the integration of fires and maneuver to achieve tactical overmatch. Current technologies should allow the development an optimized solution to cover a predetermined area of interest by the swarms of combined assets in the persistent way. In particular, this coverage will involve both mobile and stationary target acquisition and engagement assets. Some of these assets may be weaponized to engage the targets. The route patterns of moving assets can be assumed to be fixed in order to satisfy the persistent surveillance requirement. Also, periodic maintenance and refueling/recharging must be addressed. For stationary assets, the maintenance requirements may be significantly relaxed since the power consumption of these assets can be significantly reduced. The algorithm must also account for the possibility that assets may have the capability to fly and perch on the wall of the building, inside a cave or tunnel, on the trunk of a tree, or on other structures depending on the asset’s size, weight, and other factors. These assets might geolocate the targets and serve as potential forward observers for engaging the targets. The optimized solution should rely as much as possible on autonomy to enable assets capable to return to their place(s) of origin on with minimal communication both among assets with the operator unit controller (OUC). Special attention should also be paid to assure the collision avoidance among assets.

PHASE I: Design and develop innovative state-of-the-art software optimization algorithm for the persistent coverage of a predetermined area of interest by the swarms of assets capable of autonomous navigation. Model the algorithm's performance with data supply by assets with "fly and perch" capability. Demonstrate how the proposed algorithms will optimize the coverage provided by assets in a dynamic threat environment.

PHASE II: Develop and demonstrate a prototype capability with swarms of at least six assets autonomously navigating over a predetermined area of interest using the developmental offline software algorithms. The collaborative assets should demonstrate the capability of autonomous return to their points of origin. The prototype should demonstrate assets' ability to transition to the forward observer state from the perching and dormant states based on the appropriate input triggers to initiate collaborative target engagement. This prototype should be capable of integrating with CCDC Armaments Center supplied fires and effects architecture. Conduct testing to demonstrate feasibility of this technology for operation within a simulation environment operated by CCDC Armaments Center.

PHASE III DUAL USE APPLICATIONS: CCDC Armaments Center swarming/perching technology developed under this effort should have open architecture allowing it to be easily integrated with the tactical decision support systems and to enable swarming munition technologies. Department of Homeland security could use this capability to monitor the illegal crossings of the US borders. In addition, SOCOM could use this technology for surveillance of terrorist activities in urban places, while FBI/CIA could use it for intelligence gathering.

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KEYWORDS: Perching, autonomous UAV/UGV, swarm of UAVs/UGVs, forward observer, target engagement, weaponized UAVs/UGVs.

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A19-110 TITLE: Multifunctional Materials for Increased Lethality Munitions

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Develop novel multifunctional materials for the next-generation munitions for the long-range precision fire (LRPF) program under the Army Modernization effort to provide increased lethality and impose superiority on contested and expanded battlefield.

DESCRIPTION: With the evolution of modern battlefields, the Army is seeking a new generation of munitions to overmatch, deter and disrupt its adversaries. The next-generation of weapons aims to provide an increased kinetic advantage over increasingly complex targets, situations and at longer distances. The development and implementation of such systems will require new multifunctional materials and components with advanced effects to maintain and further extend our troops' superiority. The increased complexity of munitions, where target identification and guidance systems now occupy a larger portion of the warhead, has been made at the expense of the payload. The integration of reactive materials has been identified and demonstrated as a method to restore lethality by increasing the overall energy output of these enhanced munitions and improving system effectiveness. However, the integration of these materials has been limited by their mechanical properties.

This topic aims at further expanding the field of structural reactive materials (SRM), where a portion of the traditional ordnance is replaced with an SRM. Such multi-purpose components offer opportunities to integrate materials of high strength and density that adds additional damage mechanism to defeat the target.

The objective of this program is to develop novel SRMs with mechanical properties and density similar or superior to munition-grade steel, and capable of providing an energetic output upon initiation by detonation or high-velocity impact, while maintaining their integrity under the harsh launch conditions and flight loads resulting from the next-generation guns. Focus should also be given to the establishment of novel processing methods to ensure the rapid transition of the proposed technology into new or existing weapon systems.

This proposal shall develop and demonstrate the properties of these multifunctional materials in comparison with established inert materials. The characterization will include mechanical properties such as tensile and compression strength, density and hardness. The energetic performance of the novel SRM will be characterized by experimental testing to measure energy release and warhead fragmentation

PHASE I: Develop at least one novel SRM with a density equivalent or superior to munition-grade steel. Perform characterization experiments to establish the mechanical, thermal and energetic performance of the SRM in comparison with baseline inert material such as munitions grade steel. The minimum requirements for mechanical properties are 100 ksi tensile strength and greater than 5% elongation, while the energy release should be greater than 1500 cal/g. Conduct small scale fabrication to show manufacturing feasibility. Provide material sample to the Army POC.

PHASE II: Further develop and optimize the SRM established in Phase I using thermodynamic analysis to achieve the best combinations of mechanical and energy release properties. Characterize mechanical properties. Measure energy release and characterize warhead case fragmentation in small scale tests, such as blast chamber testing. Scale-up the manufacturing process and produce prototypes in at least 3 configurations of interest to the Army and deliver 5 prototypes from each configuration to the Army.

PHASE III DUAL USE APPLICATIONS: Transition the developed materials and related technology to a major manufacturer for incorporating this technology into next-generation munitions for the long-range precision fire (LRPF) program. To further exploit the benefits of the developed technology, form partnerships with other manufacturers for applications to the civil sectors, such as the oil well and construction industries. This technology can also be leveraged to mining applications as well as applications occur in submarine blasting, breaking log jams, breaking ice jams, initiating avalanches, timber or tree cutting, the perforation of arctic sea-ice or permafrost, glacier blasting, ice breaking, and underwater demolition.

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KEYWORDS: Next-generation munition, structural reactive materials, high strength material, high density reactive material, novel processing methods

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A19-111 TITLE: Non-Destructive Inspection of Modern Explosives and Ammunition Housings

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Develop a methodology and build a prototype to quickly perform non-destructive corrosion testing of small arms ammunition components in the field prior to use by the warfighter or during the development of new energetic materials.

DESCRIPTION: Energetic material advances have resulted in the development of several suitable lead-free replacements for lead styphnate and lead azide in munition formulations. These lead-free energetic materials could potentially create unexpected corrosive environments for traditional cartridge brass and other munition components. Further efforts to replace cartridge brass with novel lightweight and/or combustible cartridge cases creates additional unknown long-term reliability issues. Field testing of ammunition components is therefore critical in future deployments to assure weapon system effectiveness from the ammunition life cycle perspective, i.e. the time of production to the time of expenditure. Many field techniques are currently subject to a visual inspection of the small arms ammunition but recent advances in non-destructive metallurgical and material analysis allows for this inspection to be more analytically robust and time effective. This SBIR project provides the opportunity to employ these modern corrosion inspection techniques to be implemented for use in developmental stages of new energetic materials and in the field for a wide range of small arms ammunition components.

PHASE I: Develop process validity and methodology for non-destructive inspection of modern explosives and munition housings on a lab scale. Identify, develop, and test likely lead-replacement candidates against likely substrates based on the published literature. Major considerations for the success of the feasibility study include the time of inspection and quality of the reported data.

PHASE II: Based on the methodology established during the Phase I, a hand-held test cell prototype will be developed and certified to the appropriate Military standards, specifications, and UL requirements. This prototype test cell will incorporate appropriately designed small arms ammunition component tooling to provide an interface with different applications. A working prototype test cell with directions on its use will be delivered to the Program Executive Officer for Ammunition for field testing.

PHASE III DUAL USE APPLICATIONS: If this program is demonstrated to be successful, this non-destructive inspection technique for modern explosives and ammunition housings can be used in both military and civilian applications. Military applications include small arms components (5.56mm, 7.62mm, and .50 calibers), explosive munitions (M42, M55, and M61 initiators), and medium caliber (20mm, 25mm, 30mm and 40mm), as well as, potentially large caliber (60mm, 81mm, 105mm, and 120mm) ammunitions. Civilian applications include hunting, sport shooting, and law enforcement.

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KEYWORDS: Green energetics, small arms ammunition, non-destructive testing, corrosion

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A19-112 TITLE: Optical Based Proximity Sensor for Fuzing

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: The objective of this effort is to develop a small, low cost, optical based proximity sensor for fuzing applications. Once a proof-of-concept optical design is demonstrated, a cost model should be established, as well as a transition plan to bring the sensors into production. Emphasis during all phases of this project should be on developing a sensor with minimized cost and size.

DESCRIPTION: Most current fielded proximity sensor today are RF based. With the increasingly cluttered RF environments, the need for different proximity sensor base technologies has been realized.

A few key requirements for this sensor are volume <5cm^3, <150mW, -45º to +145ºF operating temperature, ability to survive high G environments (up to 50,000G), <$150 in production of 100k units per year. The targets of interest can range from indirect ground/water targets, to urban environments, along with direct fire engagements on small air targets. Standoff distances anywhere from 0.1m up to 20m could be possible.

PHASE I: During Phase I, a feasibility study of the proposed sensor concept shall be conducted to provide evidence that demonstrates the concept can meet the stated requirements. This study should identify the equipment and resources needed to prototype a device, as well as initial device designs and unit cost estimates.

PHASE II: Phase II shall begin by prototyping the initial sensor design and evaluating its performance against the stated requirements. It is expected that one or more design iterations will occur during the 2nd phase. Phase II will end with a proof-of-concept prototype that demonstrates the performance and producibility of the sensor through a gun fired test. Deliverables include quarterly progress reports, prototype hardware, a manufacturing plan, a field test and a final report.

PHASE III DUAL USE APPLICATIONS: Phase III shall begin with the execution of the manufacturing plan developed in phase II. Continued development of the sensor shall be pursued to reduce manufacturing costs. Key military applications for these devices are for end game fuzing. This technology can be expanded to commercial applications including car safety awareness systems.

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KEYWORDS: fuze, fuzing, electronic, diode, optical, laser

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A19-113 TITLE: Alternative Manufacturing Methods and Materials for Gun-Launched Components

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Research innovative manufacturing processes to create reduced-weight components that can survive high temperature and high compressive (g loading) environments.

DESCRIPTION: The US Army is in need of weight reduction for components used in gun-launched environments. In order to achieve the desired weight reduction, manufacturing processes other than the traditional subtractive types need to be explored. This project will investigate innovative materials, designs, and manufacturing methods to minimize production cost, minimize weight, and maintain the relevant performance requirements. Weight reduction of at least 50 percent as compared to the traditional component equivalent is the goal, while surviving long term temperatures storage requirements of up to 160 degrees Fahrenheit and short-term instantaneous temperature exposure of 900 degrees Fahrenheit while surviving shock loading up to 45,000 g's. Components can vary in both size and shape with a volume not to exceed 16.5 cubic inches. Specific design targets will be provided at project kickoff.

PHASE I: Investigate the feasibility and cost effectiveness of various alternate manufacturing processes and material combinations capable of surviving the gun-launch environment while significantly reducing the weight of the identified components. Define and execute a modeling and simulation test plan that will optimize component designs and material selections, and inform on the decision to switch to new manufacturing processes as well as the associated business case to do so. The best value of material/process/time is the objective. Success of Phase I will be the measured by a 50% weight reduction compared to traditional manufacturing methods utilizing the same material. Submission of a cost analysis is required but will not be used as a measure of success for Phase I.

PHASE II: Based on successful results of Phase I, develop, demonstrate, and fabricate a well-defined solution that is reproducible, and exhibits confidence in transition to both military and commercial markets. The objective is to conduct further development and optimization of the design and materials that provide the best balance to achieve the requirements, specifications, and metrics listed in this topic. The Phase II effort will significantly improve upon the performance and efficiency of the conceptual design developed under Phase I. This will include performance testing in the contractor's facility as well as simulated environment testing at a government location.

PHASE III DUAL USE APPLICATIONS: A full size prototype (drawings will be provided by the government for production of prototype component) of the best performer whose metrics include weight reduction, strength, and cost from Phase II will be delivered to the Government and integrated into a full-scale demonstration. A full TDP outlining the manufacturing process as well as material selection will be provided upon completion of Phase III. Commercial applications include automotive and aircraft engines.

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KEYWORDS: Additive manufacturing, alternate manufacturing process, light weight, high temperature, high strength, 3D printing, metal matrix, alternate materials.

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A19-114 TITLE: High Sensitivity Miniaturized Gun-hardened Aeroballistic and Geolocation Sensor Technology

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Design and develop a precise gun-hardened miniature electronics sensor suite to provide precise position, acceleration, and velocity.

DESCRIPTION: The US Army is in need of an on-board munition sensor package suite that provides the measurement capabilities of a three-axis gyroscope, a three-axis accelerometer, and a three-axis magnetometer. This innovative solution should have a footprint of 20mm x 20mm. The sensor package suite must be capable of surviving a minimum of 20,000 Gs. If the proposed solution relies on an external battery, the sensor package must operate on 3.7 volts with a maximum power consumption of 45 watts. A solution with a 20-year shelf life, EMI resistance, and compatibility with military operating and storage conditions is desired.

PHASE I: The contractor shall investigate the feasibility of development of the sensor package and provide a trade-off analysis for the desired measurement capabilities, form factor, cost, and shelf life. The trade-off analysis must include alternate sensor specifications as well as any possible additions to the package for operational improvements. A preliminary sensor package design must be completed by the conclusion of phase I.

PHASE II: The contractor shall provide the final design of two possible sensor packages based upon the outcome of Phase I along with input from US government. The final designs components that can be readily manufactured. After final designs have been agreed upon, one prototype of the fully assembled board for each design will be delivered for testing at a US government lab. Manufacturing partners should be engaged early in the phase II process to ensure manufacturability and to shorten the timeline for fielding.

PHASE III DUAL USE APPLICATIONS: Four fully assembled boards will be provided to USG for final testing and verification. The final product will be based upon input from initial test results provided by USG to contractor from Phase II. The contractor will update the board layout and form factor based upon results from Phase II and government requirements for size. A final TDP package must also be delivered to the government as closeout of this phase.

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KEYWORDS: gyroscope, accelerometer, magnetometer, sensor package, electronics

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A19-115 TITLE: Synthetic Aperture by Direct Print-down of Micro-lens Arrays on CMOS Imagers

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Design, develop, prototype and demonstrate the ability to form an array of wide field of micro-lenses that can be directly printed down on a Complementary metal–oxide–semiconductor (CMOS) imager. These lenses can either be compound, Gradient Index (GRIN), Freeform, or other. The intent is use such an array in a light field optical configuration to yield a very thin, light camera package that is both fast and compact in size and weight.

DESCRIPTION: The necessity for snipers, soldiers, and crew served weapons operators to rapidly and accurately detect targets on the battlefield is a capability that is of high interest to the department of defense, across all agencies. It is our desire to create a compact camera system that has a wide field of view as well as high resolution. Commercially we can find an exemplar in the Lytro approach. Other configurations can be found in "Spatio-Angular Resolution Tradeoff in Integral Photography" [T. Georgeiv et. al. Eurographics Symposium on Rendering, 2006).

Any given micro-lens will have a very short focal length. We can make the focal length small robust if we form the lenses directly on the CMOS imager as suggested by Thiele et al. in Sci. Adv. 2017; 3:e1602655. The effective aperture is that of the array. It is expected that eventually these imagers/lens arrays will be further clustered to produce very large effective apertures. The clustered effective aperture need not be circular, but may be configured in such a way as to nest on a platform, such as a rifle. In such a case the aperture could wrap around the barrel, thus yielding not only a compact package, but one that would allow for passive ranging and three-dimensional image reconstruction as well.

PHASE I: Identify materials, methods and models integrated lens arrays that are compatible with CMOS imagers. Model the optical systems to ensure that the lenslet arrays will yield suitable image quality for later image reconstruction.

PHASE II: Create an array on a CMOS imager. This imager should be functional and allow one to read out each of the sub-images. Transfer the readout into a computer and demonstrate that light field reconstruction is viable. Contractor shall clearly state in the proposal and final report how the phenomenology provides the unique capability for achieving the design goals. Make an array of the lenslet/CMOS imager modules and show that the subsampled synthetic aperture is functional.

PHASE III DUAL USE APPLICATIONS: Optimize the physical properties for military applications. Prototype a rifle mounted fire control sight using this technology that demonstrates the benefits in performance over currently fielded systems. Replace conventional electro-optics with the design in a sight that represents the optical performance of a fielded military small arms sighting system. Test and report the results of the optical metrology/performance and weight savings. Create a partnership with industry to commercialize the technology and improve the manufacturability. The prototype will be TRL 4 at the end of phase III

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1. "Spatio-Angular Resolution Tradeoff in Integral Photography" [T. Georgeiv et. al. Eurographics Symposium on Rendering, 2006).

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KEYWORDS: Conformal Optics

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A19-116 TITLE: Integrated 2-color thermal polarimetric sensor and deep neural network system for artificial intelligence and machine learning (AI&ML) based automatic target detection and identification

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop a 2-color mid and long-wave infrared (MidIR and LWIR) thermal polarimetric camera system with incorporated artificial intelligence and machine learning (AI&ML) capability for enhanced target detection and identification.

DESCRIPTION: During the past decade two different technological areas have advanced significantly, i.e., thermal polarimetric camera systems and AI&ML capabilities for data analysis and exploitation. Currently, DoD spend many tens of millions of dollars per year developing and testing thermal sensor systems designed for 24/7 day/night surveillance capabilities for a wide variety of tactical scenarios, e.g., detection of buried landmines and IEDs, identification of camouflaged/hidden targets, and night-time facial recognition.[1-4]
The advances in AI&ML are driven by new algorithms, notably deep neural networks (DNN), and the maturation of graphical processing unit (GPU) technology optimized for intensive matrix computations. The latest AI&ML algorithms can be trained relatively quickly on low cost GPUs to perform inference on GPUs in real-time. In particular, deep convolutional neural networks (CNN) have demonstrated their potential for accurate object detection and classification. [5-8]
In order to exploit these advances in polarimetric imaging and AI&ML, we propose the development of an “integrated” multimodal thermal imaging and data exploitation system designed to provide “real-time” scene understanding and situational awareness. Such a system would greatly reduce the time and cost required to bring soldier specific image based solutions to the battlefield.
To provide 24/7 day/night operation we limit the image modalities to be considered to a 2-color (MidIR and LWIR) polarimetric image system.[9-11] Assuming 2-color polarimetric operation, the possible image modalities are the conventional thermal images in each band, S0(MidIR) and S0(LWIR) and their polarimetric counterparts, i.e., Stokes images, S1 and S2 in each band, i.e., S1(MidIR), S2(MidIR), S1(LWIR), S2(LWIR). Additional modalities to be considered are various linear/non-linear combinations of the aforementioned Stokes images, e.g., degree-of-linear polarization (DoLP) image in each band, DoLP(MidIR), DoLP(LWIR). This image stream is expected to be analyzed in real-time by the AI&ML algorithms in order to produce maximum situational awareness. As a result, this system is expected to provide unprecedented target/anomaly detection performance for a large variety of DoD related applications.

PHASE I: During the initial solicitation candidates must identify 1) the optical design proposed for the 2-color polarimetric camera system, and 2) hardware, architecture, and algorithm(s) for the AI&ML operation of the system. As a result, during the Phase I candidates will be expected to conduct a feasibility study which will consist of predictive analysis and/or preliminary prototype development in support of their proposed polarimetric/AI&ML design. This should include identifying and assessing (with costs) all critical components necessary to develop the proposed system. Specifically, the candidate should define and identify particular focal-plane-array (FPA) architecture, readout circuitry, minimum integration time, optical design, spectral responsivity, and control/analysis hardware and software required for high resolution, high frame-rate operation. Analysis should include optical design modeling and optimization in which both radiometric and polarimetric response characteristics are predicted, e.g., expected noise-equivalent-delta-temperature (NEDT), and noise-equivalent-delta-polarization state (NEDP).

PHASE II: Based on the design criteria established during the Phase I, the candidate will procure all necessary components in order to assemble, test, and demonstrate a fully functional prototype device. Initial prototype development and testing will include both laboratory and field-based assessment in which standard image quality metrics will be determined, e.g., modulation-transfer-function (MTF), NEDT, and NEDP. Testing will also include evaluation of various AI&ML algorithms based on specific test objectives, e.g., anomaly detection of hidden targets within a high clutter urban environment. Prototype testing and evaluation will be conducted at a government facility in which optimum functionality will be determined based on range, atmospheric conditions, and tactical scenario. To be conducted concurrent with the prototype development, the contractor will begin identifying all possible commercialization opportunities and partnerships necessary to successfully bring their developed intellectual property (IP) to market. Final report will include system design, experimentation findings, and commercialization plan.

PHASE III DUAL USE APPLICATIONS: Upon successful completion of Phase II, the contractor may be asked to demonstrate the full utility of the developed AI&ML augmented polarimetric imaging system to various DoD Program Managers (PMs) who have expressed interest in the developed technology. Phase III may include further modification and ruggedization depending on customer needs. Such evaluation will take place at an appropriate U.S. Army field-test facility. This will also include further maturation of the system in which reduction in size, weight and power (SWaP) will be examined. The candidate is expected to pursue civilian applications and additional commercialization opportunities, e.g., remote sensing of geological formations, enhanced surveillance for homeland/boarder security, and enhanced machine vision and inspection used in various manufacturing process.

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KEYWORDS: Artificial intelligence (AI), machine learning (ML), thermal imaging, polarimetric imaging, anomaly detection, long-wave infrared (LWIR), Mid-wave infrared (MidIR)

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A19-117 TITLE: Advanced, compact acoustic particle velocity-pressure sensory system

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop an advanced acoustic particle velocity-pressure sensory system that is compact, ruggedized, and modular for anticipated missions involving acoustic localization, signal intelligence and other uses.

DESCRIPTION: The U.S. Army is seeking research and development in acoustic particle velocity and acoustic pressure sensing technologies that can be implemented for use in acoustic signal detection, localization, tracking, and characterization. The technologies must be highly modular and capable of integration into atmospheric acoustic detection systems both current and future. Technologies focusing on modular design are highly desired. An environmentally self-aware system is envisioned.

Current microphone array systems are used to detect, localize, and classify acoustic sources. Dependent upon the source and range of interest, these systems have large foot prints, ranging from several to tens of square meters. The Army seeks reduced Size, Weight, and Power (SWaP) systems. Systems that not only reduce the array system footprint, but also reduce power are highly desired.

Versatility of usage is important, as sources of interest may be harmonic or impulsive, transient or continuous. Systems may be deployed in a variety of outdoor environments, to include, urban, desert, mountainous, and littoral. Ruggedized systems that can withstand environmental extremes are a necessity for outdoor emplacement. Systems may be land-based or airborne, on the move or stationary.

PHASE I: The company will define and develop a concept for a compact acoustic particle velocity (three-dimensional)-pressure sensory system (APV-P) with modularity to include environmental state measurements (APV-P/E) that meets the requirements as stated in the topic description. The company will demonstrate the feasibility of the concept in meeting Army needs and will establish that the concept can be developed into a useful product. Material testing and analytical modeling will establish feasibility. The concept development effort should assess the importance of several acoustic sensing factors for the APV-P, such as dynamic range, wind noise mitigation, signal fidelity, preservation of waveform, sampling rates, well-defined calibration, and ease of calibration. Evidence of design optimization of these parameters, as well as a comparison between model predictions and measured performance are required. Modularity of the acoustic-environmental APV-P/E system, to include integrating meteorological sensors, should be established. Environmental parameters to be measured include wind velocity (speed and direction), humidity, temperature, and atmospheric pressure.

Plans for implementing the APV-P will be included as an output of Phase I, along with estimated performance. The APV-P will be designed to operate at frequencies between 0.1 Hz to 10 kHz, but demonstration below 0.1 Hz is also desired. The minimum dynamic range of the APV-P should be -10 dB to 150 dB, though a larger range, on both sides, is desired. Methods to manage different sound levels should be considered, such as adjustable gains. Data acquisition should have a minimum sampling rate of 25 kHz, with a minimum of 24-bit resolution. Sensitivity of the particle velocity detection should be established to correspond with the sensitivity of the pressure sensing. Of particular concern is calibration of the system; methods for in-field, self-calibration are desired. Operational conditions also should be considered, the APV-P/E system should fully function between -30 to 70 degrees Celsius, though a larger performance range is desired. A ruggedized system is required, being able to operate in severe environments, including rain and fine-particulate environments. Environmental parameter sampling should provide for atmospheric (thermal-mechanical) turbulence characterization at the acoustic scales.

PHASE II: Based on the results of Phase I, the company will develop a prototype APV-P/E for evaluation. The prototype will be evaluated to determine the capability in meeting performance goals and Army requirements. System performance will be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters. Evaluation results will be used to refine the prototype into a design that will meet Army requirements. The APV-P system should include wind noise mitigation. Documentation should include analyses comparing system response to scientific grade microphones, performance for harmonic and impulsive sources, direction finding compared to conventional systems (including azimuth, elevation, and ranging sensitivity), assessment of wind noise mitigation, and preservation of acoustic waveform.

PHASE III DUAL USE APPLICATIONS: The company will support the Army in transitioning the technology for Army field use. The company will develop an APV-P/E system according to the Phase III development plan for evaluation to determine its effectiveness in an operationally relevant environment. The company will support the Army for test and validation to certify and qualify the system for Army use and transition the APV-P/E to its intended platform. The envisioned military applications of the APV-P/E system include: detection, localization, tracking, and classification of a variety of sources, to include sniper and small-arms fire, rocket launches, explosions, and ground and airborne vehicles; characterization of atmospheric turbulence; and studies of acoustic wavefronts. A compact design is envisioned, allowing emplacement on ground and air vehicles. PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The APV-P/E system has commercial applications that include gunshot detection and localization, aircraft/unmanned aircraft vehicles localization and tracking, intruder detection, environmental hazard assessments (e.g., volcanic and tornadic activity), and acoustic tomography of the atmosphere. The commercial market is typically quick to adopt technology that enhances performance while controlling cost and reducing SWaP. The company is expected to pursue civilian applications and additional commercialization opportunities.

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KEYWORDS: acoustic pressure, acoustic particle velocity, microphone, acoustic vector sensor, self-aware sensor

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A19-118 TITLE: Image data compilation based on accurate registration of sequential frames from a drone

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Provide algorithms capable of compiling information from multiple frames acquired from a moving unmanned aerial vehicle. This algorithm will consolidate video data from an unnamed air vehicle in the form of data vectors that represent ground locations from multiple angles of observation.

DESCRIPTION: U.S. Army RDECOM CERDEC Night Vision and Electronic Sensors Directorate is supporting protection of combat vehicles through detection of obstacles that threaten maneuverability in battlespace environments. We are developing sensors mounted on unmanned air vehicles to detect and localize landmines, natural or manmade topography, and surface obstacles that limit maneuverability or threaten the combat vehicle.

To aid in this goal we will collect data over an environment from multiple look angles to improve our knowledge of the objects or conditions at ground locations. We believe that having multiple samples at a ground location will produce better features for subsequent algorithms. A necessary precondition of this process is to sort data from pixelated images of the video into vectors of data associated with particular ground locations, thus capturing a location’s data from multiple positions.

We seek assistance in this area from qualified companies who can implement algorithms that will identify terrain features from multiple video frames collected by an airborne imaging system. Algorithms should process this data to determine 3D point clouds and subsequently assign to these points data associated with that location from multiple cameras and look angles.

Topography and surface objects in the scene should be accounted for in the algorithms to appropriately register data to particular ground locations. The means of achieving this objective may include, but are not limited to, structure from motion, image transforms and photogrammetry. It is desirable that 3D information about the environment be obtained as an intermediate product. A potential benefit of this level of processing is the ability for the algorithm to discriminate above ground clutter from surface level terrain or obstacles. Likewise, information about the relative attitude of the air platform would be beneficial. Contractor data may be used to develop the algorithms, but as these algorithms mature Government provided data will be utilized to assess performance on data collected at Government test sites.

The algorithm’s objective will be to accurately register image data to ground locations from multiple imaging systems mounted to the same platform. This algorithm will preferentially operate using image data alone. Inertial Measurement Unit (IMU), Global Position System (GPS), and height data may be brought to bear if significant improvements to output quality are achievable; however preference is given to methods that operate in GPS denied environments. Subsequent detection processing of the assembled feature vectors should be considered in the context of improving resolution and registration accuracy, but this solicitation is does not encompass advanced automatic target detection development.

PHASE I: This effort should identify algorithms capable of registering image data to ground locations. Preliminary testing of contractor or modeled data should be performed to determine the ground sampling density achievable as a function of standoff distance, magnification and pixel size. The impact of optical distortions, frame rate, range of collection and nadir vs. slanting look angles should be characterized to guide future data collection activities. The final report will include the expected performance as a function of system parameters and sufficient information to determine the necessary conditions for sensors and platforms to achieve accurate image registration to ground locations.

PHASE II: This effort will implement the algorithm as software to produce 3D point clouds and associated image intensity data from Government data. Data assessment methods will be developed to determine the accuracy and stability of algorithm for various controlled data collections as well as field conditions without fiducial targets. The algorithm will show a path to continuous operation at realistic frame rates. The algorithm will be implementable on processing hardware scaled for size, weight, and power appropriate for an unmanned aerial vehicle. The algorithm should be demonstrated on such a processor or demonstrated to specify the processing and computation needs required. Resolution is desired on the order of 10cm for select regions of interest. Thus, the holistic algorithm may require trivial pre-screener processing to limit processing regions requiring improved resolution. The Phase II final report will include detailed system (software and hardware) design, system capability and limitations, detailed summary of testing and results, lessons learned, critical technology and performance risks.

PHASE III DUAL USE APPLICATIONS: The Phase III goal is to develop and implement accurate image registration algorithms on processors for UAVs. This may be combined as a complete product for commercial sales, or as an algorithmic add on that utilizes Government or commercial sensors and platforms. This phase will improve accuracy of the methods and produce consistent feature vectors of image data associated with locations in the scene.

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KEYWORDS: Structure from motion, image registration, optical flow, unmanned aerial vehicle

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A19-119 TITLE: Deep Generative Modeling of Infrared Datasets for Aided Target Recognition

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop and demonstrate techniques and algorithms for Deep Generative Modeling for the creation of Infrared (IR) datasets to facilitate Machine Learning and Aided Target Recognition (AiTR).

DESCRIPTION: Applications of Deep Learning and Machine Learning to imagery and video have been dramatic in the last decade. However, these achievements have been almost entirely based on visible band imagery and video. The data requirements of these algorithms are enormous, and developers have been able to rely on masses of readily available visible band data. Militarily significant IR data does not currently exist in the quantities and varieties necessary to fully leverage the advantages of Deep Learning. What is needed a set of techniques and algorithms which can artificially generate militarily significant (as in specific localities and target types) IR video and imagery in entirety and to augment existing IR data with novel prescribed objects and targets. Success and promise has recently been shown by Generative Adversarial Networks. However, these image constructions are mostly intended for visual effect. Much higher fidelity is essential to training AiTRs. Also artificial IR modeling systems exist at Night Vision and Electronic Sensors Directorate (NVESD). This effort aims at overcoming data limitations listed above and enhancing realism of current NVESD modeling systems. The goal is to support an IR AiTR effective fieldable system—enhancing vehicle threat detection and avoidance. This effort directly supports Army Modernization Priority: Next Generation Combat Vehicle (NGCV)—benefitting the automation associated with the NGCV through improved algorithm performance. This effort will enable NGCV sensors to rapidly determine external threats and alleviate operator fatigue via automation of surveillance and navigational functions.

PHASE I: Show proof of concept for Deep Generative Modeling algorithms for IR imagery and video synthesis. Show proof of concept for algorithms to greatly improve realism of synthetic imagery. Integrate algorithms into comprehensive algorithm suite. Test algorithms against existing NVESD modeling methodologies. Demonstrate feasibility of techniques in creating IR video sequences. Distribute demonstration code to Government for independent verification. Successful testing at the end of Phase 1 must show a level of algorithmic achievement such that potential Phase 2 development demands few fundamental breakthroughs but would be a natural continuation and development of Phase 1 activity.

PHASE II: Complete primary algorithmic development. Complete implementation of algorithms. Test completed algorithms on government-controlled data. System must achieve 25% improvement in classification rate and false alarm rate over AiTR algorithms trained on real imagery alone (using government baseline AiTR algorithm). Principle deliverables are the algorithms. Documented algorithms will be fully deliverable to government in order to demonstrate and further test system capability. Successful testing at end of Phase 2 must show level of algorithmic achievement such that potential Phase 3 algorithmic development demands no major breakthroughs but would be a natural continuation and development of Phase 2 activity.

PHASE III DUAL USE APPLICATIONS: Complete final algorithmic development. Complete final software system implementation of algorithms. Test completed algorithms on government-controlled data. System must achieve 25% improvement in classification rate and false alarm rate over algorithms trained on real imagery alone (using government baseline AiTR algorithm). Documented algorithms (along with system software) will be fully deliverable to government in order to demonstrate and further test system capability. Applications of the system will be in NVESD Multi-Function Display Program, vehicle navigation packages, and AiTR systems. Civilian applications will be in night surveillance, crowd monitoring, navigation aids, and devices requiring rapid adaptation to new environments.

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KEYWORDS: Deep Learning, Generative Adversarial Networks, Aided Target Recognition, Neural Networks, Infrared Video

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A19-120 TITLE: Novel Integration Technologies for Infrared Focal Plane Array Application

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Evaluate, develop and demonstrate the novel application of emerging commercial technologies for heterogeneous integration of infrared photodetector arrays and CMOS-based multiplexing circuitry.

DESCRIPTION: The Army needs the highest performance infrared sensors for tactical and strategic overmatch. Mission-specific applications for high-sensitivity sensors extend across multiple infrared bands, including long wavelength (8-12 microns). These requirements have led to the development of infrared focal plane arrays (IRFPA) with large formats (~ megapixel) and small pixel pitch (~ 10 micron). Such IRFPAs consist of an array of photodetectors hybridized to a CMOS-based multiplexing circuit (ROIC), which reads out the photo-generated current to create useful imagery and information. ROIC design has evolved to improve sensor performance and to include more on-chip functionality, such as digitization and signal processing. Most current IRFPAs are fabricated using flip chip (C4), die-to-die bonding/interconnect processing. Technological developments in commercial, three-dimensional (3D), wafer-to-wafer level integration are leading to interconnect densities [1, 2, 3] relevant to state-of-the-art IRFPA applications. Such 3D integration offers potential, significant cost savings for IRFPA fabrication, particularly, if wafer-to-wafer integration can be realized. However, many technical challenges and uncertainties exist to such an implementation, including, but not limited to: limited thermal tolerance of typical infrared devices; wafer size mismatch between detector and ROIC; potential contamination/diffusion issues associated with interconnect materials (Cu, W, Sn etc.); compatibility with cryogenic operation, to include thermal cycling reliability. Non-technical challenges need also be considered such as: actual cost benefits, given the potential technical constraints, relatively small production quantities [4]; security, trustworthiness of hardware, foundry etc. [5]. The goals of this project are: to evaluate and analyze 3D integration technologies in the context of IRFPA hybrid assembly; to develop/modify a 3D integration process compatible with a relevant IRFPA product; to implement, demonstrate, test and evaluate, in hardware, application of 3D integration to a relevant IRFPA product. For the purposes of this project, an IRFPA product that is relevant to Army requirements is defined by the following characteristics: cryogenically operated; cut-off wavelength > 5 microns; format > 640 x 480 pixels; pixel pitch < 15 microns.

PHASE I: The performer shall evaluate and analyze 3D integration technology in the context of IRFPA fabrication: i.e. detector array to ROIC hybridization. This analysis shall include technical, cost and security considerations. This analysis shall consist of a trade study of various processes and parameters constrained by compatibility with IRFPA processing and operation: for example, comparison of wafer-to-wafer, die-to-wafer and die-to-die integration modes. Based upon the results of this analysis, the performer shall develop a plan to develop, to implement and to demonstrate 3D integration technology in an IRFPA product that is relevant to Army requirements.

PHASE II: The performer shall design and develop a 3D integration process that is compatible with a relevant IRFPA product based upon analysis and planning of Phase I. The performer shall implement, demonstrate, test and evaluate the resulting process, in hardware, in a relevant IRFPA product.

PHASE III DUAL USE APPLICATIONS: The performer shall transition technology to appropriate foundries and/or industries for commercial implementation of resulting processes, products and/or intellectual property. Dual use applications include: machine vision, autonomous vehicles, security, process control, environmental monitoring, scientific instruments, and astronomy.

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KEYWORDS: infrared focal plane array, IRFPA, 3D integration, heterogeneous integration, wafer bonding, direct bonding, interconnect, hybridization, flip chip bonding.

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A19-121 TITLE: Foveated Headworn Display Demonstrator

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop and demonstrate a foveated headworn display that uses an eye tracker to determine eye location and provides high resolution to the display where the eye is pointed and lower resolution to other areas of the display for power, heat, and bandwidth reduction.

DESCRIPTION: High resolution microdisplays are essential for providing the human interface to high resolution digital sensors and wide field of view augmented and mixed reality vision systems used for Soldier Lethality. Reduction of power, bandwidth, and head borne heat of these microdisplays is important for all DoD application, but it is especially important for untethered infantry. The resolution of the eye is very high in the area of the fovea, but it is greatly reduced in all other areas, so most of the resolution on a wide field of view large format microdisplay is not being used – only the part within the eye's fovea is. A 2,048 x 2,048 reconfigurable microdisplay capable of reduced power operation with a moveable full-resolution window within a field of reduced resolution has been developed under government contract and is available as GFE for this effort, but an alternative display solution is also acceptable. Coupling a reconfigurable display with an eyepiece and an eye tracker would allow power to be saved by keeping the high-resolution area of the display only where the fovea is located. This project would determine if a foveated display can provide sufficient performance compared to a 100% full resolution display while reducing power and bandwidth. The Offeror shall develop a foveated HMD demonstrator that includes an eye tracker to determine the eye pointing location and thereby keep the high-resolution foveal display spot in synch with the user's line of sight.

PHASE I: Create a notional design for the demonstrator. Build a demonstrator that can be large scale (desktop display and computer) that shows eye tracking and reduces the resolution (electronically or optically) of the display in areas outside the fovea (TRL 4).

PHASE II: Build demonstrator with an eye tracker and >1080p HMD (can use GFE Reconfigurable Display) that can be reconfigured with its own electronics or with software/hardware built by the Offeror that includes a reduction in power in the foveated mode vs. full resolution (TRL 5). The demonstrator will be used to examine the visual performance for detecting and responding to peripheral visual cues based on the interaction of the foveal area profile vs. the reduced display resolution threshold in the peripheral zone. The demonstrator will include a way to measure the power for full vs. reduced resolution.

PHASE III DUAL USE APPLICATIONS: Implement the foveated display design into a military HMD, possibly partnering with a HMD manufacturer (TRL 6). Address integration issues, cost, and power reduction vs. design complexity.

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KEYWORDS: Microdisplay, foveated display, reconfigurable display

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A19-122 TITLE: Variable Attenuator for See-Through Day/Night Displays

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop and demonstrate a variable attenuator for head-worn see-through day/night displays suitable for military aviation and untethered infantry use. Attenuator will capable of changing from high optical transmission for an unobscured view of the environment to low transmission to enhance the contrast of the display versus the ambient.

DESCRIPTION: See-through displays, which are used for situational awareness and targeting for Soldier Lethality and Future Vertical Lift, can be overwhelmed by high level ambient light such that the content of the display is not readable. A contrast of 1.2:1 of the display to the background is the general rule for see-through readability, with the worst-case ambient conditions being 2,000-fL for a white cloud or snow bank on a clear day. Reducing the transmission of the see-through optic, such as a visor, can aid with display contrast and readability, but the transmission needs to be high in some operations, especially at night, to allow the user to see details in the real environment through the optic. Arbitrarily driving the brightness of the display source brighter would enable readability, but it may increase power and thermal management demands beyond allowable limits, especially for untethered infantry. It also limits the display and optical technologies available for augmented reality solutions. See-through displays are also subject to external hazards and threats that occluded systems are not. A continuously variable attenuator can allow full daylight readability in bright ambient conditions, a clear view of the real world in night operations, and can have built in protections against hazards and threats. One potential form of the variable attenuator will be to provide the ability to transition bi-directionally between a broad-band, visually neutral, low transmission state of not more than 20% and a broadband, optically neutral, high transmission state of at least 80% in under 1 second. Other potential variable attenuator implementations for consideration include video rate attenuation switching speeds, localized and/or tailorable spectral attenuation/switching, and integrated eye/display hazard and threat protection. This effort will include the development of the 80%/20% ambient transmission attenuator and will also include its integration into a headworn system. An automatic adjustment of the transmission is optional, but a manual adjustment override is essential. Hazard and threat protection is also optional.

PHASE I: Complete a notional design and model performance for a variable attenuator for day/night readability. Address spectrum, level of attenuation, switching speeds, localized attenuation, and potential hazard and threat protection. Provide sample demonstrators of attenuator technology (TRL 4). Phase I demonstrators may utilize planar substrates.

PHASE II: Refine system design and build lab demonstrator capable of a minimum of 80%/20% continuous variability (spectrally flat) and will include other design concepts Offeror intends to include, such as localized attenuation (TRL 5). Develop a fully functional demonstrator that is integrated with a see-through head worn display (TRL 6). This demonstrator will examine the commercial practicality and cost related to implementing the variable attenuator on curved and/or plastic substrates.

PHASE III DUAL USE APPLICATIONS: Integrate with a military AR HMD, possibly partnering with an HMD manufacturer for this effort (TRL 7). Apply technology to larger HUDs in aircraft and to vehicle windows. Implement hazard and threat protection if not already included.

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2. Russell S. Draper et al., "Electrochromic Variable Transmission Optical Combiner", SPIE Proceedings Volume 5801, Cockpit and Future Displays for Defense and Security (2005)

3. Thomas H. Harding, Clarence E. Rash, "Daylight luminance requirements for full-color, see-through helmet-mounted display systems", SPIE Optical Engineering Vol. 56 Issue 5 (2017)

4. Thomas H. Harding et al., "HMD daylight symbology: color choice and luminance considerations", SPIE Proceedings 10197, Degraded Environments: Sensing, Processing, and Display (2017)

KEYWORDS: Attenuator, optical attenuator, variable attenuator, see-through display, augmented reality, HMD, HUD

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A19-123 TITLE: Advanced Concepts for Low-Cost High-Speed Uncooled Infrared Detectors

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Exploration of advanced concepts for high-performance, low-cost, uncooled infrared detectors and focal plane arrays for soldier systems

DESCRIPTION: Exploitation of recent advances in electronics, optoelectronics, communications, and quantum computing may provide future breakthroughs in infrared detectors, offering promising opportunity for soldier-worn sensors. Examples of these advances include colloidal semiconductor quantum dots, quantum wire carbon nanotubes, and graphene with combined structures that could potentially enable highly beneficial detector designs for photoconductors, photodiodes, or field effect transistors (1-3). These and similar technologies may be the future steps for high-speed, compact, lightweight, and low-cost sensor operation.

In this topic, high-speed, high-performance infrared detector concepts operating at room temperature are being pursued to support small, lightweight, low-power soldier sensor systems that perform better than current imagers. Detectors should operate at very high speeds like quantum detectors, and at room-temperature like bolometers.

For the future Army dismounted soldiers, low cost and small size, weight and power (SWaP) infrared sensors are critical to equip our soldiers in the battlefield. This topic has significant impact on the CFTs Soldier Lethality, as well as Future Vertical Lift and Next Gen Combat Vehicles.

The detailed detector performance includes but is not limited to 1) High speed at 120Hz operation, 2) High performance comparable to or better than the current bolometers at room temperature, 3) Suitability for large format, small pitch focal plane array fabrication, 4) Compatibility with existing readout integrated circuitry for detector integration, and 5) Cost lower than current bolometers.

Detectors should operate at room temperature with a D* of ~1E10 Jones and response time in the millisecond range. The cutoff wavelength can be in the long- or mid-wavelength infrared spectrum. It is highly desired to have the capability to capture a thermal image without light. Low-light-level, visible or near infrared detectors will also be considered. A suitable digital readout integrated circuit (ROIC) should be identified for uncooled detector use.

PHASE I: In Phase I, an innovative detector concept should be modeled and designed and detectors should be grown and processed to demonstrate single element diodes.

PHASE II: The innovative concept should be demonstrated at the infrared focal plane array (FPA) level with frame rate at >120Hz and performance similar to current bolometers at room temperatures.

PHASE III DUAL USE APPLICATIONS: Develop and execute a plan to market and manufacture the new focal plane arrays (FPAs). Assist Army in transitioning this technology to the appropriate Prime Contractor(s) for the engineering integration and testing. The contractor shall pursue commercialization of the various technologies and electro-optic/infrared (EO/IR) components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, environmental monitoring sensors, maritime and aviation collision avoidance sensors, medical test equipment, homeland defense surveillance, and other infrared detection and imaging applications.

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KEYWORDS: Uncooled infrared detectors, focal plane arrays, quantum detectors

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A19-124 TITLE: A point-of-care assay to determine soldier dengue exposure and enable rapid, mass, cost-efficient dengue vaccination programs of military personnel

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop a specific cost-effective point-of-care assay to rapidly identify dengue exposure history in the warfighter enabling force protection readiness and high-throughput mass dengue vaccination programs

DESCRIPTION: Dengue virus (DENV) is a growing threat to tropical regions and the warfighter. It is a leading cause of fever in military deployed to tropical regions [Gibbons, EID, 2012], and the global incidence of dengue has dramatically increased in the last three decades [Messina, Trends Microbiol, 2014]. DENV infections may lead to loss of operational readiness and maybe life threatening and difficult to manage in austere settings [WHO, https://www.ncbi.nlm.nih.gov/books/NBK143157/, 2009]. The four dengue virus serotypes complicate risk management and readiness. First dengue infections are often asymptomatic and dramatically increase the chance of a more severe infection when exposed to a second dengue serotype [Soo, PLOS One, 2011].

Clinical trials have shown that dengue vaccines are less effective and potentially dangerous when administered to those who have not been previously exposed to dengue, as is the case with the majority of the US Military [Sridhar, NEJM, 2018; Gibbons, EID, 2012]. The World Health Organization now recommends that determining dengue exposure history (serostatus) is critical to inform what vaccine strategy should be used in order to maximize dengue protection and avoid vaccine related harm [Vannice, Vaccine, 2018].

Immunological assays which can detect prior exposure to dengue do exist, but they are not point-of-care [Welch, J Virol Methods, 2014]. Moreover, standard immunoassays such as ELISA lack specificity to DENV as they cross-react to other flaviviruses, particularly Zika virus (ZIKV), and may cross react with Yellow-Fever and Japanese Encephalitis vaccine-derived antibodies [Priyamvada, PNAS, 2016]. The current, approved, gold-standard to accurately determine dengue exposure history is to use plaque-reduction neutralizing assays (PRNT). However, PRNTs are cumbersome, require a specimen send-out to a central reference laboratory, have low reliability between laboratories, and are costly [Rainwater-Lovett, BMC ID, 2012]. The turn-around time for a PRNT result is too long when large-scale dengue vaccine programs are underway, particularly for time-sensitive mass deployments. Waiting for PRNT results would be unfeasible even for routine recruit basic training vaccination programs. A more specific ELISA assay has been recently developed, but this is non-FDA approved and there is limited, if any, clinical experience with its use [Balmaseda, PNAS, 2017]. This assay was designed primarily as a clinical ZIKV diagnostic assay. Moreover, this assay is not point-of-care and requires laboratory expertise for use and interpretation [Balmaseda, PNAS, 2017]. Other point-of-care diagnostic assays for dengue are designed to detect acute infections, not prior dengue exposure [Zainah, J Virol Methods, 2009]

A rapid, point-of-care assay which measures dengue exposures of recruits would allow immediate determination of whether a warfighter can be vaccinated for dengue, and/or whether the warfighter requires a different dengue vaccine product or schedule. This would be vital for time-sensitive dengue vaccination programs of large volumes of troops before deployment when it would not be possible to obtain their serostatus in a feasible time frame. It would also remove the need to perform thousands to millions of expensive, time-demanding PRNT assays in existing Department of Defense laboratories which currently do not have the capacity to perform such a large volume of reference dengue diagnostic tests.

A point of care dengue specific exposure device will reduce risk of any current or future dengue vaccine and pre-deployment dengue exposure testing will identify soldiers and general population that are at increased risk of severe disease when traveling or deploying to high risk dengue regions of the world.

Of note this device would not be an acute disease diagnostic to identify pathogens causing fever and dengue disease. While current acute point-of-care febrile disease diagnostic platforms can estimate primary versus secondary dengue infection, they are calibrated and validated to do so only during an acute febrile illness and they cannot accurately detect prior dengue exposure in the asymptomatic host which would typically have far lower circulating levels of anti-flavivirus antibodies.

PHASE I: By the end of Phase I the successful applicant will have:
(i) Conceptualized the assay to include potential targets of dengue verse other related flavivirus specificity and demonstrate with design and data package supporting claims of specificity.

(ii) Conceptualized and defined the target assay characteristics including a) biospecimen type (e.g. blood, sera), biospecimen volume required and proposed route of access (e.g. fingerstick, 1mL of sera derived from venipuncture); b) analyte of interest (e.g. antibody class) and method of detection; c) envisaged assay read out (e.g. colorimetric, digital); d) anticipated field operating characteristics including assay thermostability, cold chain requirements, necessary reagents, and operator skill required to perform and interpret the assay; and e) crude cost estimate for each assay unit
(iii) Developed technological milestones for the full development of this assay
(iv) Outlined a set of performance goals for the validation of this assay, including in-vitro validations and subsequent clinical validations
(iv) Explicitly described the target protein(s), antigen(s) or antibody(s) or other analytical target, including their reproducible functional and structural characteristics While the awardee is expected to select an appropriate target analyte, they are strongly encouraged to co-ordinate the choice of antigen/antibody with the COR

Specifically, the awardee will have:
• Performed the assay in a research laboratory setting and demonstrated that it can be performed without any laboratory infrastructure (i.e., demonstrated the feasibility of point-of-care use).
• Performed the assay in a research laboratory setting and demonstrated the feasibility of using only a relatively small amount of biospecimen which would be readily available in a point-of-care setting (using a small amount of biospecimen) to detect the analyte.
• Evaluated the prototype product on a pilot panel of flavi-virus exposed and unexposed biological specimens available through the COR

PHASE II: The Phase II deliverables will include:
(i) Construction and demonstration of the operation of the assay prototype
(ii) A detailed plan for clinical validation
(iii) Performance of a clinical validation of the assay on archived or prospectively collected bio-specimens from humans and higher order animals with known exposure to DENV, ZIKV, other flaviviruses and flavivirus vaccines already determined by gold-standard methods. This validation will include metrics of assay validity and reliability, with estimates of uncertainty around these metrics. This validation must address the broad genetic and antigenic diversity of DENV by global location. The expected performance parameters would be a sensitivity greater than 90% and a specificity greater than 90%, although the target performance characteristics may depend on the setting of use (see Phase III) and the pre-test probability of disease exposure and can be coordinated and refined with the COR.

PHASE III DUAL USE APPLICATIONS: The expected Phase III end-state is an FDA approved, low-cost, point-of-care, closed-system, easy-to-use and easy-to-interpret assay which can be used on a relatively low volume of easily accessible biospecimen. The transfer from research to operational capacity would occur via the biotechnological industry pathway, such that appropriate scale up and feasible unit costs can be accommodated.

This end-product would likely be used in vaccination clinics during basic recruit training and/or in vaccination clinics as part of large-scale pre-deployment soldier readiness programs. It is envisaged that this point-of-care test that could be operated by a nurse or other healthcare professional in the office without the need for laboratory expertise. The specific indication would to immediately determine a soldier's dengue serostatus, permitting an on-the-spot decision about which vaccine product/schedule they need to receive (including a decision whether it is safe for the soldier to receive any dengue vaccine at all). A similar consumer group may be civilians presenting to a travel clinic for pre-travel dengue risk advice and vaccination.

This end-product would also be critical for civilian population dengue vaccination programs and we would envisage it would be used on a population scale in dengue endemic regions to facilitate widespread dengue vaccination programs which are projected to greatly reduce the overall burden of dengue in many tropical regions, but which are currently restricted by host serostatus safety concerns. Current guidance from the WHO for the current single licensed dengue vaccine (which is now licensed in over 20 countries) is that the host dengue sero-status should be determined before vaccination [Vannice, Vaccine, 2018]. However, this may be logistically and financially prohibitive in many lower-resource regions, even if recently developed ELISA platforms are extensively validated and approved for diagnostic use [Turner, Trans R Soc Trop Med Hyg. 2018]. This envisaged product would therefore 'unlock' the full potential of currently licensed, and perhaps future dengue vaccines, to substantially reduce the burden of this disease.

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KEYWORDS: Dengue Virus, Flaviviruses, Zika Virus, Dengue Vaccines, Diagnostic Assay, Immunoassay, Serostatus, Soldier Lethality

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A19-125 TITLE: Advanced Machine Learning Target Recognition in Munitions

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Apply Machine Learning/Artificial Intelligence to target recognition algorithms in gun launched munitions.

DESCRIPTION: The Army requires advancement in Autonomous Target Recognition (ATR) algorithms for seekers in gun launched applications. Currently, seekers are capable of target detection in low clutter environments. To field a fully effective weapon that is also safe for use in conditions where there is high fratricide or collateral damage concern, the ability to discriminate between target types and between friend and foe rapidly (within minutes) and under extremely dynamic conditions is required. This topic will apply advanced and innovative machine learning and/or artificial intelligence to current and future target sensor packages that will be used in artillery, tank and mortar munitions among others. This includes but is not limited to new algorithmic approaches and/or sensor fusion approaches to improve ATR capability at extended slant ranges (3-7km), and while searching large Field of Views (FOV) (up to 3000m radius). The ability to conduct ATR in relatively inexpensive (<$10K unit at 1000 units/year) seeker architectures is critical. The munitions will experience high shock (up to 45,000 g's) throughout a range of temperature extremes (- 25 to +145 degrees F operating range). The algorithms shall be capable of operating on emerging commercial GPU products suitable to 155mm artillery SWaP-C constraints.

Detailed requirements will be provided after contract award.

PHASE I: Phase I will consist of development of prototype algorithms on representative hardware demonstrated in laboratory simulated environments. A final report will document testing results and present the top level plan to continue development in Phase II.

PHASE II: Phase II will continue the success of Phase I and integrate the hardware/firmware solution into a representative gun fired munition and tested at a government test range to demonstrate the ability to discern multiple disparate targets within the timing required in multiple environmental conditions. The result of Phase II will be a prototype design, including applicable technical data, which will be integrated into current and future munition designs for advanced target recognition.

PHASE III DUAL USE APPLICATIONS: Upon success of Phase II, these technologies would be transitioned to munitions currently in development. Commercial applications could include law enforcement, border patrol/control, wildlife tracking or any other application requiring aerial identification of specific items on the ground.

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KEYWORDS: machine learning, artificial intelligence, algorithm, munitions, ammunition, extended range, artillery, mortars, precision, target recognition, target tracking

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A19-126 TITLE: Advanced Machine Learning for Non-Destructive Testing

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Apply Machine Learning/Artificial Intelligence to aid in interpretation of radiography inspection results during non-destructive testing.

DESCRIPTION: The Army relies on radiography inspection (e.g. x-ray and neutron) for non-destructive testing of munitions during production and special investigations. Interpreting the visual results of the inspections is a challenge and requires highly trained individuals (Level III Radiographers) to determine what, if any, problems actually exist. This topic will apply advanced and innovative machine learning and/or artificial intelligence to current and future non-destructive radiography inspection methods that use electronic imaging to identify defects and aid the operator in proper and timely interpretation of the results. As this technology is meant to be incorporated in a production line, the expectation is that it will support three-dimensional inspection and interpretation of defects at a production rate of up to 1 unit per minute, and items up to 6.5 inches in diameter. Defects include cavities, porosity, piping, voids, gaps, low density, annular rings, cracks and inclusions ranging from 0.002" to 0.020". The technology must reside on a standard computer system linked to the inspection equipment and receive the electronic images from the radiography system. Specific interface requirements will be provided after contract award. This topic will also develop and deliver the output screens that provide the proper data and information that a Level II radiographer is trained to understand.

PHASE I: Phase I will consist of development of prototype algorithms on representative hardware (to be defined prior to contract award) demonstrated in laboratory simulated environments. The government may also provide actual images obtained during prior government testing. A final report will document testing results and present the top-level plan to continue development in Phase II.

PHASE II: Phase II will continue the success of Phase I and integrate the hardware/software/firmware solution into a representative radiography system at a government facility (to be defined prior to Phase II contract award). The result of Phase II will be a prototype design, including applicable technical data, which will be integrated into current and future radiography inspection systems at multiple government locations.

PHASE III DUAL USE APPLICATIONS: Upon success of Phase II, these technologies would be qualified and transitioned to inspection equipment at multiple government ammunition production and R&D facilities. Commercial applications could include medical imaging and inspection of high value and/or safety critical items.

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6. - NAS410 NAS Certification & Qualification of Nondestructive Test Personnel

KEYWORDS: non-destructive test, radiography, x-ray, n-ray, munitions, testing, machine learning, artificial intelligence, inspection

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A19-127 TITLE: Software Defined Radio Automated Testing Solution

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: The Software Communications Architecture (SCA) v4.1 is an open architecture framework that defines a standard way to instantiate, configure, and manage waveform applications running on a radio hardware platform. The SCA decouples waveform software from its platform-specific software and hardware, facilitates waveform software re-use, and minimizes development expenditures. The SCA v4.1 specification increases cybersecurity, improves performance, enhances software portability, and affords opportunities to reduce development costs of SCA compliant products.

DoD Instruction 8310.01, IT Standards in the DoD, 2 Feb 2015, states that program managers and developers will use IT standards in the DISR for IT system development, acquisition, and procurement to promote interoperability, information sharing, reuse, portability, and information security.

The main objective is to develop an automated testing platform as a dynamic testing method for the SCA 4.1 compliance requirements that necessitate the execution of the waveform under test on a SCA 4.1 Test Platform. This effort develops an extensible environment for the construction, organization, execution, and summary of automated, reproducible compliance tests on SCA 4.1 waveform products.

The JTNC Test & Evaluation Laboratory (JTEL) is the designated Test Authority of the SCA specifications compliance for the DoD and Commercial radios and waveforms.

DESCRIPTION: The desired solution will provide an automated test platform for Tactical Communications Waveforms and Applications against the SCA v4.1 specification with the following features:

- Modular and object-oriented architecture that allows separation of test description from the test execution.
- Implementation in C++ or Java without 3rd-party library dependence.
- Able to execute on both Windows and Linux platforms
- Able to read test configuration in eXtensive Markup Language (XML)
- Scriptable and GUI-configurable execution models
- Output comprehensive test reports in common formats (XML, CSV, HTML, and ASCII text)
- User manual and Software Design Description (SDD)

  Solution should be deployable on a Windows or Linux platform and connection to a tactical radio set via USB cable and/or Ethernet cable. The resultant product of this effort would be transitioned to the Joint Tactical Network Center. Commercial application of this technology could include usage by vendor SDR developers whose desire is to test their waveforms' compliance to SCA v4.1 specification.

PHASE I: The Phase One deliverable will be a prototype and product documentation describing:

- A Set of SCA v4.1 requirements that will be used in Phase 1
- Analysis of test approaches (dynamic and/or static) for the SCA v4.1 requirements

- Design and implementation of a simple GUI to allow users to select a set of SCAv4.1 requirements for testing
- Demonstrate a simple Application/Waveform test case
- Provide test results in a test report in common formats (XML, CSV, HTML, and ASCII text) showing the Application/Waveform component under test, applicable SCA v4.1 requirements, results of the test, and set of metrics (number passed vs failed).
- Document User Manual and Software Design Description

PHASE II: Phase II will provide an automated compliance test solution for SCA 4.1 requirements that are applicable to SDR Applications/Waveforms. The tool employs both dynamic and static testing approaches since some of the SCA requirements may not be verified by dynamic testing.

Phase II will provide an automated compliance test solution for SCA 4.1 requirements that are applicable to SDR Applications/Waveforms. The tool employs both dynamic and static testing approaches since some of the SCA requirements may not be verified by dynamic testing.

Phase II deliverables will include:

- Provide a complete set of SCA v4.1 requirements that are developed in Phase II
- Analysis of test approaches (dynamic and/or static) for the SCA v4.1 requirements
- Design and implementation of GUI to allow users to configure the test cases and SCAv4.1 requirements.
- Develop and demonstrate automated test tool for the SCA v4.1 requirements.
- The test tool has reached the DoD Technical Readiness Level 6 at the end of Phase II.
- Test report provides Waveform/Application components, applicable SCAv4.1 requirements, test results, and metrics
- Product documentation includes User Manual and Software Design Description
- Monthly technical discussions with TPOC and stakeholders
- Quarterly Progress reports including all technical challenges, technical risk, and progress against the schedule.

PHASE III DUAL USE APPLICATIONS: Phase III will integrate the tool developed in Phase II with the SCAv4.1 Test Suite (STS) that is developed by the JTNC Test and Evaluation Laboratory. The STS tool verify tactical radios against the SCA v4.1 specification.

Phase Three deliverables will include:

- Prototype solution suitable for supporting PM TR or any programs that sponsor or develop Tactical radios or application/waveforms
- Demonstration of the test tool with Tactical Communications Waveforms/Applications
- Complete Source code of the tool
- Test report in common formats (XML, CSV, HTML)
- Product documentation includes User Manual and SDD
- Quarterly Progress reports. The reports will include all technical challenges, technical risk, and progress against the schedule.

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KEYWORDS: Software Define Radio (SDR), Software Communications Architecture (SCA), tactical radios, tactical waveforms, tactical applications, tactical radio services, automated test tool.

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A19-128 TITLE: Intelligent Manufacturing Technologies for Lithium-ion 6T End-of-Line Testing

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: An advanced, intelligent Lithium-ion 6T manufacturing end-of-line tester and cell selector system to improve 6T battery quality & performance.

DESCRIPTION: The 28-V Lithium-ion 6T drop-in replacement battery (Li-ion 6T) is a critical technology to enhance energy storage to improve warfighting performance across the Army, Marines, and Navy. The Li-ion 6T is a drop-in replacement for legacy Lead-Acid 6T batteries for starting, lighting, and ignition (SLI) and silent-watch applications, and provides the same form, fit, and expanded function, including increased silent watch time, significantly extended cycle life, and faster recharge time. Deficiencies in Li-ion 6T manufacturing inspection technologies and processes could result in three possible undesirable outcomes: (1) battery products with latent defects, in either the cells or BMS, which causes premature failure or safety issues in the field (such as an internal cell short); (2) battery products with deficient performance for their intended function as a result of poorly matched cells (such as poor cycle life); or (3) low yield resulting in increased production cost through waste. While manufacturing technologies exist for basic cell selection and end-of-line testing, these processes could benefit substantially from innovations in cell analysis techniques, hardware-in-the loop modeling & simulation, and machine learning. Technologies developed should be specifically for Li-ion battery pack production processes versus cell production processes and should be specifically focused on cell selection at the start of the pack production process and end-of-line testing of the final product at the end of the pack production process. A Li-ion 6T battery product’s performance is directly affected by the cells chosen for the battery. Currently, cells within the Li-ion 6T battery are matched in many cases simply by capacity and internal resistance and manufacturing cell selection equipment and processes are not designed specifically with Li-ion 6T in mind. Accordingly, innovative solutions must be developed and demonstrated which will allow for enhanced cell selection & sorting as well as for Li-ion 6T battery pack end-of-line testing, designed to ensure that the military-specific SLI and silent-watch missions can be met by the final 6T product. Cell selection solutions should take into account technologies such as internal resistance measurement, internal short detection, electro-impedance spectroscopy, calorimetry, and neural networks as well as other innovative analysis techniques. Cell selection and pack end-of-line test technologies shall be capable of integration into a high-volume 6T production process of at least 500 packs/month,and should be scalable to processes of up to 2000 packs/month. End-of-line test solutions must be able to account for the whole operational voltage and temperature range of the battery as well as be capable of simulating pulse events such as cold crank. The systems and solutions developed should be open-architecture to the greatest extent possible. Solutions developed should include real-time modeling & simulation to allow for analysis of the suitability of a produced battery to meet Army requirements, such as Silent Watch.   Technology developed should be generally applicable and adaptable to all Li-ion 6T products as well as to all low-voltage commercial Li-ion battery packs. Innovative solutions developed for pack end-of-line testing shall include the ability to determine compliance to all MIL-PRF-32565 periodic production inspection (PPI) tests and have a secure way of reporting results of PPI testing to the Qualifying Activity (such as public-private key encryption). The solutions should also be capable of learning in an effort to help reduce future failures through correlation of PPI/end-of-line test data to cell selection, with the goal of preventing batteries that fail compliance from making it into the field.

PHASE I: Identify and determine the engineering, technology, and hardware and software needed to develop this concept. End-of-line test technologies developed shall include all listed PPI testing in Table VII of the MIL-PRF-32565, including: Physical characteristics, Dimensions and weights, Terminal posts and threaded sockets, Full charge capacity, Cranking amps, Charging, Charge acceptance, Safety protections, Workmanship, and Defects. Additionally, technologies developed should allow for prediction and assessment of whether the following IPI tests will be met by the battery including: Deep cycle life, High temperature deep cycle life, Retention of charge, Battery storage life, Battery service life, Surges, spikes, and starting operation, Voltage surges, Voltage spikes, and Electromagnetic compatibility/interference. Battery Management System Hardware in the Loop Simulation to determine BMS quality and compliance should also be considered to verify CAN bus requirements, “Measured parameters” tolerances, state of charge estimation accuracy, state of health estimation accuracy, and power capability estimation accuracy. Solutions developed shall improve yield and reduce waste, and consequently improve production costs, by at least 5%. Automated PPI testing using technologies developed under this effort shall reduce the time required for completion of PPI by half. Drawings showing realistic designs based on engineering studies are expected deliverables. Additionally, modeling and simulation (M&S) tools needed to drive the end-of-line tester and cell selection technology is expected. A bill of materials and volume part costs for the Phase I designs should also be developed. This phase also needs to address the challenges identified in the above description.

PHASE II: Develop and integrate prototype hardware and software into high-volume manufacturing equipment using the designs and technologies developed in Phase I. Deliverables shall include electrical drawings and technical specifications, software, M&S and test results, and at least one Li-ion 6T pack end-of-line tester and one cell selector capable of integration into a high-volume Li-ion 6T manufacturing process and production line. The end-of-line tester and cell selector shall be designed initially for processing only one type/size of Li-ion 6T cell and Li-ion 6T pack product, but the technology shall be designed such that it is generally applicable to all Li-ion 6T cells as well as to commercial cells, applications, and Li-ion pack products. Testing of the Phase II design shall include mock manufacturing runs using small production batches of Li-ion 6T cells and Li-ion 6T batteries. Integration of the technology developed and demonstration on an existing Li-ion 6T manufacturing process and production line line capable of at least 200 packs/month is expected in this phase. The scalability of the technology to high-volume Li-ion 6T production of up to 2000 packs/month should also be demonstrated based upon throughput and rate capabilities of the end-of-line tester and cell selector. A bill of materials and volume part costs for the Phase II design should also be developed.

PHASE III DUAL USE APPLICATIONS: This phase will begin installation and integration of the solutions developed in Phase II into military Li-ion 6T and commercial Li-ion pack production processes and into low- to high-volume manufacturing lines.

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KEYWORDS: Manufacturing, Lithium-ion, 6T, end-of-line testing, modeling, simulation, batteries, power, energy

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A19-129 TITLE: Advanced Signal Detection and Characterization Utilizing Artificial Intelligence (IL)/Machine Learning (ML)

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Design and build an electronic signal detection and characterization unit that utilizes artificial intelligence (AI) and machine learning (ML), that can perform continuous monitoring of the electromagnetic spectrum (EMS), and that can provide signal characteristics to an interface.

DESCRIPTION: Recent advances in the computing world has allowed for algorithmic advances in the detection and characterization of the electromagnetic spectrum (EMS). Specifically, the incorporation of such things as neural networks and training processes has elevated artificial intelligence (AI) and machine learning (ML) as key innovation areas for detecting, characterizing and cataloging highly complex signal types in the EMS. The current effort would mature these AI/ML concepts to develop a signal detection and characterization system for electronic signals. The unit would be able to detect and characterization various signal types and modulations. It would also provide performance and monitoring tools to provide real-time feedback to operators. The incorporation of data analytics for validation and visualization would be included in the unit. The system would follow a Modular, Open Systems Approach (MOSA) to allow integration into a variety of Army systems. The MOSA approach would also provide extensible ML and Deep Learning (DL) functions to expand upon key features and signal types. The system would contain only Commercial, Off-The-Shelf (COTS) products.

PHASE I: Develop system design that includes artificial intelligence (AI) and machine learning (ML) algorithms and concepts, hardware and software specifications, and protocol operation (both internal and external).

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian communication applications where equipment is susceptible to electromagnetic interference - for example, in military exercises/operations or in enhancing critical industrial operations in electromagnetic saturated environments.

Integrate the product as a prototype adjunct to an already existing tactical system/architecture. Demonstrate that the product can be integrated and utilized in a tactical system with minor modifications to include form, fit, function changes and minor interface upgrades. Demonstration will provide key decision points on interoperability, MOSA integration, and tactical feasibility.

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KEYWORDS: Artificial Intelligence, Machine Learning, Deep Learning, Signal Detection, Signal Characterization, Modular Open Systems Approach (MOSA), Commercial Off-The-Shelf (COTS)

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A19-130 TITLE: Aerostat Hybrid

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Enhancement of current Aerostat capabilities to provide Low Cost Persistent Intelligence, Surveillance and Reconnaissance (LCP ISR)) during high intensity conflicts with Class A adversaries.

DESCRIPTION: While Aerostat systems are an essential tool for support to ongoing combat operations their utility is limited during high intensity conflicts due to their static nature, inability to rapidly redeploy within theater and inability to provide persistent Intelligence, Surveillance and Reconnaissance (ISR) in support of Wide Area Operations. Despite these shortfalls Aerostats are in high demand from our coalition partners. It is anticipated that the airship functionality could potentially be obtained thru normal P3I efforts and little to no additional program costs.

Our fires community can provide strategic fires hundreds of miles further than our current sensors can currently provide persistent coverage. UAV and space-based assets are vulnerable to enemy targeting and are too expensive to provide persistent low cost wide area coverage. Once targeted UAV and space-based sensors are difficult and expensive to reconstitute in any reasonable period of time.

Desire is to implement P3I initiatives against our current Aerostat system which would provide immediate enhanced capabilities in regards to persistent & low cost wide area ISR while leveraging the current Aerostat infrastructure currently deployed. Follow on efforts would further scale this capability for use in tactical, operational and strategic missions. This would provide the Army and the department of defense a significant operational capability for Force Protection, Cyber, and Precision Fires all of which are critical capabilities for battlefield dominance and would provide a substantial procurement & sustainment savings over our current operations.

Effort would enable Aerostats to operate autonomously or as remote controlled unmanned Airships that can be statically deployed via tethers as they are now but with the ability to drop its tether and self-deploy within its theater while conducting limited wide area operations LCP ISR. Endurance for static operations would be 30 days continuous operations and 7 days during airship mode operations with an operational range of 2000 miles.

While these systems would be vulnerable to enemy targeting and destruction, the systems would be considered attributable, and due to their low cost; easily replaceable. It is anticipated that enemy action would be counterproductive due to the necessary enemy disclosure that would result.

PHASE I: Carry out a feasibility study for leveraging current commercial Airship designs for military use and demonstrate potential capabilities via use of commercial products as military prototypes. Phase I will define factors for a Phase II sensor demonstration for Fires, Cyber, and Force Protection.

PHASE II: Demonstrate capabilities using the commercial prototype for Fires, Cyber and Force Protection.

PHASE III DUAL USE APPLICATIONS: Develop prototype (aka battle type) that would be deployed into a combat theater for proof of concept assessment. Potential DoD customers/transition partners include Army program-of record Force Protection systems, US Marine, Navy Command units, USAF Security force operations, Coast Guard, Customs and Border Patrol, Nuclear Energy Commission, Homeland Security (Cruise Missile Defense) and Foreign Military Sales.

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KEYWORDS: Aerostat, LCPISR, unmanned-airship

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A19-131 TITLE: Reduced emission sensors for Short Range Air Defense (SHORAD)

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: The Army has interest in sensors with passive and low probability of intercept acquisition and weapon cueing capabilities applicable to air defense in support of Short Range Air Defense (SHORAD) system missions. Small innovative business insights to support highly survivable short to moderate range Army Air and Missile Defense (AMD) acquisition and fire control sensors initiatives is sought.

DESCRIPTION: State-of-the-Art or emerging passive or low probability of intercept sensor technologies are needed as complementary components of the SHORAD integrated sensor suite to support SHORAD unit real time Situational Awareness (SA), target acquisition and weapon cueing. The SHORAD missions require rugged, responsive, compact high precision sensors, which are capable of supporting targeting (weapon cueing as a minimum), identification/recognition and data fusion processes, while producing a reduced signature to threat counter Intelligence, Surveillance and Reconnaissance (ISR) assets. On-board passive and low probability of intercept sensors must be compatible with supported unit battlefield environments and vehicle form factors. It is expected that these requirements will drive integration of multi-spectral passive sensor / low probability of detection sensor technologies in rugged, compact form factors. The prioritized targets to be addressed are:

1. Nano- to Class III Unmanned Air System (UAS), to include individual, multiple and swarm presentations.
2. Rotary Wing/Fixed Wing (RW/FW), to include countering aircraft launched Tactical Air to Surface munitions.
3. Rocket, Artillery and Mortar (RAM) to include precision indirect fires and salvo attacks.

Sensors are required to perform target acquisition at all mission phases and to support target engagement on the move or on a short halt. Preference is for the sensor to support high volume of fire required to a large number of different target types in a combined saturation attack.

Sensors are required to perform target acquisition at all mission phases and to support target engagement on the move or on a short halt. Preference is for the sensor to support high volume of fire required to a large number of different target types in a combined saturation attack.

Sensor related elements of the kill chain include:

1. Target acquisition.
2. Fusion with other SHORAD sensors.
3. Positive identification, Identification of Friend or Foe (or classification of non-combatant).
4. Weapon cueing (with possible fire control capability) and kill assessment of kinetic and non-kinetic engagements.

PHASE I: Investigate and research technologies that can be incorporated into SHORAD systems, and are complementary to existing SHORAD sensors, to build and field sensor systems that are extremely difficult to detect, or attack, and are able to provide actionable information to the Soldier concerning active threats. Some technologies may be commercial-off-the-shelf tools that can be innovatively employed to operationally harden systems (operate with minimal signature in the battlefield ground mobile environment). Some technologies may be new and, as yet, not well known. False targets must be minimized, but sensors must provide actionable data in real time. Sensors could be signature based, behavior based or may leverage a technique that is yet to be developed. Sensors must be compatible with, or tolerate, periodic system software updates/patches, must be “soldier friendly” and supportable throughout the lifetime of the fielded system. Investigations should include estimated development and production costs (to support preliminary government budgeting activities). Once investigation and research of potential technology is complete, the offeror will, in an unclassified format, identify implementation options in a Phase 1 report.

PHASE II: Using the technology and approach(es) identified in Phase I, and adding classified Phase II technologies if needed, develop, fabricate and validate a prototype sensor. The sensor should fully address integration, size-weight-and-power (SWAP), and any system performance or impacts. A technology Readiness Level (TRL) of 5 or

6 depending on system complexity and SHORAD system availability (TRL 5 - Component and/or breadboard validation in relevant environment / TRL 6 - System/subsystem model or prototype demonstration in a relevant environment) is required to support initial sensor evaluation activities and possible incorporation into the SHORAD equipment set.

Given a viable technical approach and performance, estimate and refine development, support and production costs to be included with technical concept data and delivered prototype implementation.

PHASE III DUAL USE APPLICATIONS: Transition the Phase II product into a fieldable sensor prototype for detailed technical and operational testing. Following testing, perform cost/ manufacturability/ performance optimization and prepare sufficient data products to support potential procurement and fielding with the Army AMD sensors, weapons, and/or with other potential systems.

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KEYWORDS: Passive sensor, Electro-optical/Infra-red, bi-static, multi-static, low probability of intercept, weapon cue.

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A19-132 TITLE: Next Generation Aviation Helmet Shell

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Improve ballistic performance of the HGU-56P helmet through retrofit or replacement of the helmet shell and/or lining foam.

DESCRIPTION: Improved armor protection is a fundamental component of lethality, one of the six army modernization priorities of the Army. Current ballistic protection of the HGU-56P helmet is limited to a .22 caliber, 17-grain, T37 FSP. Multiple ballistic material technologies have been published in the last year suggesting ballistic improvement to the aviation helmet can be achieved with minimal weight increase. These include graphene:

https://www.azonano.com/article.aspx?ArticleID=3934

Diamene:

https://www.materialstoday.com/carbon/news/diamene-looks-like-graphene-acts-like-diamond/

Nanomaterials:

http://zeenews.india.com/news/space/paper-thin-material-that-can-stop-flying-bullets-created_811129.html

Sheer thickening fluids:

http://www.foxnews.com/us/2017/06/02/air-force-cadet-creates-bulletproof-breakthrough.html

Structured polymer composites:

https://theweek.com/articles/470303/bulletproof-super-material-thats-paperthin

Composite metal foam:

https://www.dailymail.co.uk/sciencetech/article-3529765/The-bulletproof-FOAM-turns-gunshot-dust-Material-used-make-lightweight-body-armour-protect-cars.html

This solicitation intends to identify ballistic improvement solutions that can be applied to the existing helmet as a retrofit or replacement of the shell or foam with the least amount of weight increase and/or structural changes and quantify the improvement. Objective is to provide US National Institute of Justice (NIJ) Level II (9mm) ballistic protection. Current helmet shell protection is called out in 1680-ALSE-101, Aircrew Integrated Helmet System Fabrication Specification.

PHASE I: This effort shall create a study identifying the most promising ballistic improvement technologies allowing retrofit of the aviator helmet with the lowest weight and cost to enable production. The study shall also project durability and retrofit time for each solution. A demonstration of ballistic performance of the technology proposed is required. Options for introduction of the new material(s) proposed include retrofit of the existing helmet (most desirable), replacement of the helmet shell, replacement of the helmet liner foam, or replacement of both the liner and foam (lease desirable). Ballistic improvement can be projected as a function of keeping total helmet weight equal or less than existing helmet of each size. i.e., if technology proposed will not improve ballistic performance over existing helmet weight, then that technology should be considered a "no-go". A threshold requirement of 10% ballistic improvement to the existing helmet is required as an entry criteria for Phase II.

PHASE II: The best two solutions identified in phase I will be used to build or retrofit a helmet and tested to quantify ballistic improvement. Four helmet(s) will be furnished to the vendor for retrofit and ballistic testing. The retrofit process for the helmet will be documented for each solution. A summary report at the end of the study shall document ballistic performance improvement of each solution, identify exact weight impact to the helmet, identify retrofit time and cost of each solution and assess durability of each solution. If acceptable ballistic improvement is found without unacceptable increase in weight, a new set of tests will be performed to ensure the helmet still meets all requirements of the PRODUCT SPECIFICATION, Aircrew Ballistic Helmet (ABH), HGU-56/P Shell and Maxillofacial Shield (MFS). The contractor shall update the product specification with the new ballistic performance capability to reflect the improved armor protection and a projection of increased weight based on prototype production. Perform bench testing for all helmet specification requirements on production representative prototypes. Government will supply an additional thirty six (36) helmets to be retrofitted to support bench and field test/evaluation for all requirements of the helmet specification.

Deliverables will include test plan, test report, updated helmet specification reflecting measured improvement in ballistic performance, minutes for all meetings conducted with the vendor, presentation slides for retrofit application of ballistic material, a white paper detailing the retrofit process of the ballistic material, and a cost report detailing retrofit cost as a function of helmet quantity from a minimum of 50 and up to 1000 at a time.

PHASE III DUAL USE APPLICATIONS: Develop production processes for best retrofit solution found in Phase II. Update the helmet item specification to reflect final production process weight. Aviation helmets used throughout DOD may find retrofit application for this same process. Commercial jet engines may find an ultra light coating application capable of resisting turbine blade failure causing injury or death to a passenger aircraft.

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KEYWORDS: Aviation Helmet, Ballistic Performance

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A19-133 TITLE: Power Generation for Individual Soldier

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Develop, design and fabricate a Soldier wearable power generation device that can provide power in all operational environments across the range of military operations from training, full-scale war and counter-insurgency operations to peacekeeping, support and reconstruction operations.

This topic addresses lighter tactical power generation that increases the ability to operate semi-independently; a critical enabling technology to the Soldier Lethality Army Modernization Priority.

DESCRIPTION: Currently, the individual Soldier's mobility is constrained, in part, by the necessity to carry extra batteries and/or man-portable power generation and battery charging equipment, to meet the power demands of the equipment he/she carries. The Power Generation for Individual Soldier device shall provide a minimum of 6 watts of continuous uninterrupted power for 24 hours. The device, including fuel source as applicable, shall have a volume not to exceed 50 cubic inches and shall not weigh more than 2.5 pounds (lbs). No dimension shall exceed 12 inches. It shall operate during day and night.

PHASE I: Develop overall system design and provide a performance specification as part of the Final Technical Report. Include unit cost projections in the Technical Report. A breadboard demonstration of proposed design is encouraged.

PHASE II: Design, fabricate and demonstrate a prototype system in an operational relevant environment. Deliver two TRL 6 prototypes to the Government. Deliver Final Technical Report, which includes a product specification and estimated unit production cost.

PHASE III DUAL USE APPLICATIONS: A wearable power generation system has multiple uses in military and civilian operations. Besides the obvious first responders' and outdoors' types of applications, this device could potentially end the current problem with handheld and other power consuming devices, where their batteries run out of power before consumers have a chance to find a place to plug in. With the constant growth of wireless services and the capabilities of wearable devices, current battery technology is not keeping up with power consumption. This could be the solution. Phase III shall consist of the development of the producibility of this item for military use.

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KEYWORDS: wearable, power, generation, continuous, lightweight, small

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A19-134 TITLE: Real-time Muzzle Velocity Feedback System (RMVFS)

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: To increase overall Soldier Lethality Capability by providing ballistic calculators, weapon fire control devices, and related apps, with immediate, real-time muzzle velocity information after each shot fired to automatically update ballistic computations to enhance accuracy of follow-on shots.

DESCRIPTION: Muzzle velocity is the speed of a projectile at the moment it leaves the muzzle of a gun and a key parameter in determining a projectile’s external/exterior ballistics (i.e. flight profile and trajectory). Small arms exterior ballistic calculations, used to predict an aim point in order to hit a target, are based on either estimated muzzle velocities or measured muzzle velocities which are typically taken when zeroing a weapon and before executing a mission. However, muzzle velocities will typically change over time and during operational-use based on several dynamic factors to include barrel cleanliness and wear; rate-of-fire; variations in ammunition composition; ammunition and bore temperatures; and (when available) weapon suppressor conditions. Real-time muzzle velocity measurements, provided in a closed-loop feedback schema, would allow fire control and ballistic calculators to better account for and compensate for these unknown and constantly changing variables, thereby increasing aiming accuracy and probability of (target) hit on successive shots. It is envisioned that this measuring device would eventually be affixed to or incorporated within a weapon barrel. The closed loop feedback between the muzzle velocity measurement device and ballistic solver(s) would be accomplished via either hard-wired or wireless communications. This effort would ultimately increase mission effectiveness and overall soldier lethality.

PHASE I: Research and propose a viable cost-effective technical solution that satisfies the stated objective. In order to expedite an initial proof of concept, PMSW would like to focus on applying this desired capability to current medium-to-long range sniper weapons since 1) sniper teams require the utmost in aiming accuracy and 2) they currently rely on muzzle velocities with ballistic solvers in determining scope reticle offset holds for target engagements. Potential applicable sniper weapon platforms for consideration include the 7.62mm M110 Semi-Automatic Sniper System (SASS), the .300WinMag M2010 (bolt-action) Enhanced Sniper Rifle (ESR), .50 Cal M107 (semi-auto) Long Range Sniper Rifle (LRSR), and future Precision Sniper Rifle (a multi-caliber 7.62mm/.300NM/.338NM weapon). It is envisioned that once proven, the technology could be scaled to other mission area weapons as fire control capabilities proliferate, especially with Next Generation Squad Weapons.

As such and to facilitate Phase I efforts, a surrogate sniper weapon, optic, and ammunition, comparable to the M110, should be used. Likewise, use of a surrogate (computer/smart-phone based) fire-control ballistic solver would be acceptable, but ultimately, PMSW would like initial integration with the Kestrel 5700 Elite Weather Meter with Applied Ballistics, which was recently adopted in Fiscal Year (FY) 2017 by the Army as its Ballistic Weather Meter (BWM) and added as a component to the Advanced Sniper Accessory Kit (ASAK). PMSW would also like the measurement accuracy of this device to be within +/- 1% of the actual (Doppler radar measured) bullet muzzle velocity. This accuracy is commensurate with the Government tested accuracy of the Magnetospeed Ballistic Chronograph (Part #: MS V3BT), which was also adopted by the Army, as its Small Arms Ballistic Chronograph (SABC), and added to the ASAK in FY 2015. Some other investigative constraints to consider include 1) that size and/or form factor does not adversely affect shooter operation; 2) that the device can be mounted/installed in conjunction with and will not interfere with other existing or planned weapon devices (such as existing mounting rails, suppressors, bipods, sight posts, etc…); 3) that the device must not alter the inherent baseline accuracy of the host weapon system; 4) that the device can withstand and operate within anticipated weapon operational shock and temperature ranges; and 5) that the device shall be able to operate within and not adversely contribute to Electromagnetic Environmental Effects (E3).

The proposed solution should be the result of an engineering tradeoff analysis conducted among several possible courses of action with a focus on SWaP-C (size, weight, power & costs) considerations. The analysis should detail technical advantages/disadvantages, as well as technical/programmatic risks, and provide rough cost estimates for a fieldable technology. All work performed in Phase I shall be provided in a final report that identifies the best conceptual solution. Breadboard tests to demonstrate technical feasibility are encouraged.

PHASE II: Design, develop, build, and deliver six (6) prototype Real-time Muzzle Velocity Feedback Systems based on Phase I recommendations that can be demonstrated with a weapon platform that is comparable to the M110 SASS. The M110 SASS is a militarized variant of the commercially available 7.62mm SR-25 from Knight's Armament Company. The RMVFS is intended to integrate with a ballistic solver software to effectively use that muzzle velocity data to calculate real-time exterior ballistics and provide any adjusted aim-points. The system needs to be tested to prove that the RMVFS muzzle velocities meet the objective accuracy requirements and that muzzle velocity data can be passed and used in real-time by a ballistic solver. Phase II culminates with a report that includes test and demonstration results. A detailed proposal will be developed that delineates required efforts to have a TRL-7 system available to be demonstrated in a military environment as a potential Phase III follow-on effort.

PHASE III DUAL USE APPLICATIONS: In conjunction with a military customer, optimize and ruggedize the Phase II prototype system for possible integration with Army small arm fire control systems / ballistic solvers and insertion within Army combat teams. The system has potential commercial applicability for law enforcement, hunters, and target shooters.

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KEYWORDS: WEAPON, AMMUNITION, MUZZLE VELOCITIES, AIM POINT, FIRE CONTROL, EXTERNAL, EXTERIOR, BALLISTIC CALCULATIONS, CHRONOGRAPH

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A19-135 TITLE: Powder Development and Characterization for Additive Manufacturing of FeMnAlC Alloy Steel

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: This project seeks the development of an additive powder with the same composition as the lightweight armor steel, FeMnAl, for future repair of components made of this steel, and design of new components.

DESCRIPTION: FeMnAl is a lightweight, high-strength steel alloy with Fe-28Mn-9.5Al-1Si-0.5Mo-0.9Cdeveloped for armor applications. The Army is interested in using this steel to reduce weight in a variety of ground vehicle platforms. While a high-alloy steel, it is a single phase, with age-hardenability. This means there are fewer concerns with rapid solidification, as martensite cannot form, and heat treatment can be used to control the hardness of the final part.

Similarly, there is growth in the development of additive manufacturing repair techniques for ground vehicles. However, there is not currently a similar high-alloy steel powder available.

Additive repairs requires compatibility with this high alloy steel, which in turn requires unique powder compositions. The unique chemistry of this alloy is expected to be challenging, and require innovative processes to manufacturing in powder form. This steel has been produced via traditional metal manufacturing techniques, in both cast and wrought forms. No attempt has been made to develop a powder form of this material.

PHASE I: In Phase I, the small business will assess the capability to make high alloy powders near this composition. This powder will be compatible with Directed Energy Deposition, with a powder size of 60 to 125µm. Compositional validation will be required. High rating will be placed on compositional evaluation using wet chemistry methods, due to known limitations of optical emission and spark spectroscopy for this composition. Feasibility of process will be demonstrated by production of a small batch of powder of the intended composition. Deliverables shall include materials data and physical powder samples.

PHASE II: In Phase II, the small business will improve processing to make powder within compositional tolerances, targeting uniformity throughout the batch. This phase will include characterization of the powder produced by various metrics [Slotwinski], and manufacture of test articles, such as density, hardness, and metallographic samples. The final deliverable will include:

- Composition testing results
- Material test results
- Documentation of powder characteristics (size distribution, particle density, particle morphology, particle crystalline phases)

PHASE III DUAL USE APPLICATIONS: In the final Phase of the project, the contractor will determine capability to produce the powder in larger scales, and develop a strategy for qualification. The final powder should easily transition to customers interested in light weighting, particularly in wear-sensitive regions. Powder would be made available to Programs of Record, such as PdM Abrams, for purchase and use for repair of their systems in which FeMnAl has been integrated. It may also be used in future design of specific components with significant weight restrictions.

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KEYWORDS: Steel, additive manufacturing, powder metallurgy, metallic alloys

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A19-136 TITLE: 2kW Solid Oxide Fuel Cell (SOFC) Power System

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Development of a man-portable 2kW SOFC system with 13kW power spikes. System to power robotic vehicles, ground vehicle auxiliary systems or exoskeletons. System durability will be increased as well.

DESCRIPTION: Solid Oxide Fuel Cell (SOFC) systems allow for power generation using hydrocarbon fuels (such as JP-8, propane, butane or methane) which are readily available, instead of hydrogen gas, which is not as easily obtainable and requires additional storage and/or equipment to use and produce. In addition, SOFC systems also have high power densities (1), high electrical efficiencies (1), a lower acoustic signature than internal combustion engines (2), produce water as a byproduct (3), have the highest tolerance for sulfur in the fuel of any fuel cell type (3) and do not require the use of precious metal catalysts for operation (3).

These advantages make SOFC systems (i.e. stack and balance of plant components) useful as auxiliary power sources to charge batteries on robotic vehicles and exoskeleton systems, run peripheral equipment to alleviate power consumption from the main power plant, export power from the vehicle to power stationary devices and have the ability to run near-silent for silent watch operations. Despite these advantages, SOFC stack technology used in today's light-weight, man-portable systems are not capable of suppling enough power in the space-claim provided and also have low system durability. Smaller scale SOFC systems currently exist that would fit into a similar space claim as proposed here, but the power supplied by those systems is lower than 2kW. The 2kW of power generated by the SOFC stack, with the system capable of up to 13kW intermittent power spikes using internal batteries, proposed in this topic is viewed as an adequate starting power for use with robotic vehicles, auxiliary systems on ground vehicles and exoskeleton systems.

Advancement of new novel materials used within the system construction (such as catalysts used in electrode construction and oxygen transport materials used in electrolyte construction), increased catalyst loading, optimized system design and innovative geometries used in stack design to increase active surface area can all be investigated and developed to address this issue.

The SOFC system (i.e. SOFC stack, internal batteries for 13kW power, fuel and balance of plant components) will have the following requirements in addition to meeting the 2kW power. The system will have a power density of at least 94 W/kg or have a total mass of 45 kg while having a total system volume of 4,000 cubic inches or less. The system will produce 36-48V of electricity and be able to supply power using the attached fuel source for 4-5 hours continuously. The system will be able to thermally cycle between 50-100 times without the SOFC system power degrading below 2kW (excluding internal battery power). The system will be able to operate for at least 1,000 hours (combined operation time or single continuous use) without the SOFC system power degrading below 2kW (excluding internal battery power). The system will have a start time of 30 minutes or less to achieve 2kW of continuous power with 13kW intermittent power. The target system cost, for commercialization purposes, is expected to be between $5,500/kW and $8,000/kW based on projected system costs from the DOE. The system will be capable of being operated with compressed hydrogen gas or with light hydrocarbon fuels (such as butane, propane or methane). These system requirements are standard with less compact SOFC systems, which should be preserved for this more compact system as well (4), (5).

PHASE I: This phase will focus on conducting a feasibility study to determine the best approach to achieve the SOFC systems requirements listed above. This study will be used to identify materials and different fabrication approaches that will allow the SOFC system to achieve the desired system power output. The feasibility study will also focus on methods of increasing system durability and methods of eliminating failure points during operation.

PHASE II: Phase II will focus on optimizing the SOFC system design and conducting durability experiments. Experiments will be conducted in stages first by using single cells or short stacks (5-cell stacks). Stack size will then gradually be increased and each new stack size will be tested to identify degradation and durability failure modes until a full stack passes testing criteria. SOFC system power will be increased to 2kW by conducting experiments on the system to identify points of parasitic losses and novel approaches of manufacturing the SOFC system to minimize those losses through different material choices or system design. A preliminary investigation should also be completed in order to determine the cost of fabricating the SOFC devices and stacks.

PHASE III DUAL USE APPLICATIONS: The system should be scalable to provide power to the military in such areas as: 1. Robots and exoskeletons used for reconnaissance and bomb disposal, 2. Drone aircraft used for reconnaissance and short to medium ranged strikes, and 3. Auxiliary power to ground vehicles to save energy costs and for silent watch capability. The system should also be scalable for the commercial market to provide power in areas of: 1. Power generation for homes, 2. Auxiliary power for ground commercial vehicles, and 3. Auxiliary power for light commercial aircraft. The system should also conform to particular dimensions of a space claim and provide the required amount of power for each application.

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