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

INTRODUCTION

The US Army Research, Development, and Engineering Command (RDECOM) is responsible for execution of the Army SBIR Program. Information on the Army SBIR Program can be found at the following Web site: https://www.armysbir.army.mil.

Solicitation, topic, and general questions regarding the SBIR Program should be addressed according to the DoD Program Solicitation. For technical questions about the topic during the pre-release period, contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period, visit http://www.dodsbir.net/sitis. Specific questions pertaining to the Army SBIR Program should be submitted to:

John Smith
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US Army Research, Development and Engineering Command (RDECOM)

ATTN: AMSRD-PEB
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Aberdeen Proving Ground, MD 21005-5201
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The Army participates in three DoD SBIR Solicitations each year. Proposals not conforming to the terms of this Solicitation will not be considered. Only Government personnel will evaluate proposals.

Please note, due to recent changes in SBIR policy, Phase II efforts following a Phase I award resulting from the 11.1 and subsequent Solicitations will have a maximum dollar amount of $1,000,000. Phase II efforts following a Phase I award prior to the 11.1 Solicitation will continue to have a maximum dollar amount of $730,000.

PHASE I PROPOSAL SUBMISSION

Army Phase I Proposals have a 20-page limit including the Proposal Cover Sheets (pages 1 and 2 are added electronically by the DoD submission site---Offerors are instructed to NOT leave blank pages or duplicate the electronically generated cover pages THIS WILL COUNT AGAINST THE 20 PAGE LIMIT), as well as the Technical Proposal (beginning on page 3, and 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). Therefore, a Technical Proposal of up to 18 pages in length counts towards the overall 20-page limit. ONLY the Cost Proposal and Company Commercialization Report (CCR) are excluded from the 20-page limit. As instructed in Section 3.5. d of the DoD Program Solicitation, 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 over 20-pages will be deemed NON-COMPLIANT and will not be evaluated. This statement takes precedence over Section 3.4 of the DoD Program Solicitation. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed 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 4.2 of the DoD Program Solicitation.

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.

COST PROPOSALS

A firm fixed price or cost plus fixed fee Phase I Cost Proposal ($150,000 maximum) must be submitted in detail online. Proposers that participate in this solicitation must complete Phase I Cost Proposal not to exceed a maximum dollar amount of $100,000 and six months. A Phase I Option Cost Proposal not to exceed a maximum dollar amount of $50,000 and four months. The Phase I and Phase I Option costs must be shown separately but may be presented side-by-side in a single Cost Proposal. The Cost Proposal DOES NOT count toward the 20-page Phase I proposal limitation. When submitting the Cost Proposal, the Army prefers the small businesses complete the Cost Proposal form on the DoD Submission site, versus submitting within the body of the uploaded proposal.

Phase I Key Dates

Phase I Evaluations	October – November 2012
Phase I Selections	December 2012
Phase I Awards	January 2013*

**Subject to the Congressional Budget process*

PHASE II PROPOSAL SUBMISSION

Army Phase II Proposals have a 40-page limit including the Proposal Cover Sheets (pages 1 and 2 are added electronically by the DoD submission site---Offerors are instructed to NOT leave blank pages or duplicate the electronically generated cover pages THIS WILL COUNT AGAINST THE 40 PAGE LIMIT), as well as the Technical Proposal (beginning on page 3, and 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). Therefore, a Technical Proposal of up to 38 pages in length counts towards the overall 40-page limit. ONLY the Cost Proposal and Company Commercialization Report (CCR) are excluded from the 40-page limit. As instructed in Section 3.5. d of the DoD Program Solicitation, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool. Army Phase II proposals submitted over 40-pages will be deemed NON-COMPLIANT and will not be evaluated. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 40-page limit.

Note: Phase II proposal submission is by Army invitation only.

Generally, invitations to submit Phase II proposals will not be requested before the fifth month of the Phase I effort. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in Section 4.3 of the DoD Program Solicitation. 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 Solicitation very carefully. Phase II proposals will be reviewed for overall merit based upon the criteria in Section 4.3 of the solicitation.

Invited small businesses 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. Army Phase II cost proposals must contain a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of $1,000,000. During contract negotiation, the contracting officer may require a cost proposal for a base year and an option year. These costs must be submitted using the Cost Proposal format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Proposal 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 base year prior to extending funding for the option year.

BIO HAZARD MATERIAL AND RESEARCH INVOLVING ANIMAL OR HUMAN SUBJECTS

Any proposal involving the use of Bio Hazard Materials must identify in the Technical Proposal 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 2.3 of this solicitation for definitions of “lawful permanent resident” and “protected individual”] as key personnel, they must be clearly identified. **For foreign nationals, you must provide technical resumes, country of origin, and an explanation of the individual’s involvement. 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.

SBIR FAST TRACK

Small businesses participating in the Fast Track program do not require an invitation. Small businesses must submit (1) the Fast Track application within 150 days after the effective date of the SBIR Phase I contract and (2) the Phase II proposal within 180 days after the effective date of its Phase I contract. See Section 4.5 in the DoD Program Solicitation for additional information.

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 proposal for Phase I ($100,000 maximum), Phase I Option ($50,000 maximum), and Phase II ($1,000,000 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://cmra.army.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 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 six 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/sbir/TechnicalAssistance.aspx.

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 contracts. The size and timing of these enhancements is dictated by the specific research requirements, 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/SmallBusinessPortal/Default.aspx and is due within 30 days of the contract end date.

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.

ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 12.3 Topic Index

Participating Organizations		PC	Phone
Aviation Missile RD&E Center (AMRDEC A)		**Linda Taylor**	**(256) 876-2883**
A12-104	Foil-Air Bearings for Small Gas Turbine Engines		
Aviation Missile RD&E Center (AMRDEC M)		**Otho Thomas**	**(256) 842-9227**
		Dawn Gratz	**(256) 842-8769**
A12-105	Instrument for Measuring Millimeter-Wave Polarimetric Bidirectional Reflectance Distribution Function		
Armaments RD&E Center (ARDEC)		**Carol L'Hommedieu**	**(973) 724-4029**
A12-106	Bio-Inspired Processor		
JPEO Chemical and Biological Center		**Larry Pollack**	**(703) 767-3307**
A12-107	Rapid Analysis of Suspicious Powders		
A12-108	Ultra-Sensitive, Room-Temperature, Mechanical-Optical-Cavity Detectors for Long-Wavelength Applications		
Medical Research and Material Command		**JR Myers**	**(301) 619-7377**
A12-109	A Real-Time, Non-Invasive Monitoring System to Guide Accurate Fluid Resuscitation of Combat Casualties During Pre-Hospital and Transport Medical Care		
A12-110	Local Active Noise Reduction for MEDEVAC and CASEVAC		
A12-111	HCI and C2 for Autonomous Air Evacuation of Casualties		
A12-112	A New Generation of Actuators for Robotic Systems		
A12-113	Temperature-Controlled Transport Container for Packed Red Blood Cells		
A12-114	Automated, Enroute Combat Casualty Care		
A12-115	Rapid Extraction of Arthropod Nucleic Acids for Diagnostic Testing		
A12-116	High Flow, Extended-Wear Respirators for Ambient Particulate Matter Protection		
A12-117	Adapting SmartPhones for Ocular Diagnosis		
PEO Ground Combat Systems		**Erik Kallio**	**(586) 282-0203**
A12-118	SiC 600VDC Solid State Circuit Protection and Distribution		
Tank Automotive RD&E Center (TARDEC)		**Martin Novak**	**(586) 282-8730**
A12-119	Optical Communications for Control of Unmanned Ground Vehicles		

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

This is a Checklist of Army Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets the Army SBIR requirements. You must also meet the general DoD requirements specified in the solicitation. **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 **$100,000** with up to a six-month duration) AND (if applicable) an optional effort (up to **$50,000** for an up to four-month period to provide interim Phase II funding).

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

____ 3. The technical content of the proposal, including the Option, includes the items identified in Section 3.5 of the Solicitation.

____ 4. **Army Phase I Proposals have a 20-page limit including the Proposal Cover Sheets (pages 1 and 2 are added electronically by the DoD submission---Offerors are instructed to NOT leave blank pages or duplicate the electronically generated cover pages THIS WILL COUNT AGAINST THE 20-PAGE LIMIT), as well as the Technical Proposal (beginning on page 3 and 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). Therefore, the Technical Proposal up to 18 pages in length counts towards the overall 20-page limit. ONLY the Cost Proposal and Company Commercialization Report (CCR) are excluded from the 20-pages. As instructed in Section 3.5, d of the DoD Program Solicitation, 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 over 20-pages will be deemed NON-COMPLIANT and will not be evaluated. This statement takes precedence over Section 3.4 of the DoD Program Solicitation. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 20-page limit.**

____ 5. The Cost Proposal has been completed and submitted for both **the Phase I and Phase I Option** and the costs are shown separately. The Army prefers that small businesses complete the Cost Proposal 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 Proposal (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 proposal.

____ 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 identified in the proposal. An employee must have an H-1B Visa to work on a DoD contract.

Army SBIR 12.3 Topic Index

A12-104 TITLE: Foil-Air Bearings for Small Gas Turbine Engines

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Improve small gas turbine engine system weight and performance by developing foil-air bearings to support the main rotor shaft (s).

DESCRIPTION: Small gas turbine engines for unmanned aerial systems and man-portable electric power generators need to be as light and efficient as possible to meet mission requirements. These small gas turbine engines currently use oil lubricated, conventional ball bearings that operate at very high rotational speeds. The frictional loss of these high speed bearings represents a 5-10% loss in power. Also, the weight of the required lubrication and bearing cooling system approaches 30% of the engine system weight. Advanced foil bearings for small gas turbine engines have the potential to eliminate a large portion of these performance and weight penalties.

The use of air foil bearings for small gas turbine engines has been hampered by several significant technical challenges. These challenges include bearing surface velocities above current industrial applications, the need for small compact bearing sizes with thin material sections (foils) and small well controlled clearances. Also, these small bearings need to provide high levels of radial and axial stiffness to maintain tight/well controlled compressor and turbine clearances for good engine performance. In addition, the air-foil bearings need to provide adequate damping to control rotor motion as critical speeds are encountered and balance deteriorates during field usage. Lastly, high temperature rub materials need to be validated for these thin foils that must operate through a large number of start/stop cycles in military applications. This effort seeks to develop air foil bearings for gas turbine engines with a maximum output power of up to 200 hp.

PHASE I: Investigate compact foil-air bearing concepts and select candidate rub materials for high-speed, small gas turbine engine applications through modeling, empirical evaluation, pragmatic analysis and laboratory tests. Complete foil-air bearing preliminary design for the most attractive concept(s). Substantiate the weight savings of the foil-air bearing configuration in comparison to a conventional rolling-element bearing and sump layout (as a percentage of total engine weight, for target engine size). Also, the foil-air bearing shall be designed to a minimum of 1000 hours life.

PHASE II: Design and fabricate an air bearing test rig, air bearing concept and small gas turbine engine modifications as necessary to accommodate foil-air bearings. Complete rig and small gas turbine engine tests to validate the foil-air bearings. Develop a dual use commercialization plan. Design to weight and life metrics as described in Phase I.

PHASE III: Work with the Government and industry to construct a prototype small gas turbine engine system with advanced foil-air bearings. Conduct extended durability testing over typical military and civil use cycles. Pursue global commercial markets for this new small gas turbine engine technology.

REFERENCES:
1. L. “Foil Air/Gas Bearing Technology: An Overview.” American Society of Mechanical Engineers 97-GT-347 (1997): n. Web. 12 Oct. 2011.

2. C. and, Mark J. “Load Capacity Estimation of Foil Air Journal Bearings for Oil-Free Applications.” NASA/TM 209782 (2000).

3. H. “Advancements in the Performance of Aerodynamic Foil Journal Bearings High Speed and Load Capacity.” STLE Transactions Vol. 41, 3 (1998): 335-340.

4. P., Locke, D.H. and, H. “New-Generation Development Rigs for Testing High- Speed Air-Lubricated Thrust Bearings,” STLE Transaction, Vol. 46, 4 (2003): 556-559.

KEYWORDS: foil-air bearings, bearings, small gas turbine engine, unmanned aerial system, weight reduction, engine performance

A12-105 TITLE: Instrument for Measuring Millimeter-Wave Polarimetric Bidirectional Reflectance Distribution Function

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Construct an instrument to measure the millimeter wave polarimetric bidirectional reflectance distribution function of objects.

DESCRIPTION: Millimeter-wave (mmw) RADAR techniques may exhibit advantages over other imaging methodologies for aiding navigation in degraded visual environments, providing high-resolution terminal missile guidance, and detecting wires and small-caliber threats. Surprisingly, there is very little information about the bidirectional reflectance distribution function (BRDF) of objects in the mmw region and how it depends on waveband or polarization. The transition from Ka-band to W-band to G-band involves more than just shorter wavelengths and their commensurate technological challenges; it also involves a change in the nature of the scattering problem. Millimeter-sized structures and imperfections significantly change the RCS of objects that would appear smooth at longer wavelengths, so when targets must be separated from clutter, different wavebands and polarizations will discriminate different features. Contributions from surface roughness and millimeter-sized features increasingly dominate the BRDF of an object, producing a combination of Lambertian and specular scattering. Lambertian scattering from man-made structures may be caused by surface corrugation, abrasion, rust, or corrosion, for example, while Lambertian scattering from terrain, grass, and foliage may also depend on environmental conditions (esp. hygroscopicity and wind). Specular reflection may come from surface imperfections like cracks, dents, fasteners, facets, corners, and edges that act as antennas or retroreflectors in a manner that may or may not be sensitive to the object’s orientation and the RADAR’s polarization.

Measurements of the polarimetric BRDF of potential targets and unintentional scatterers (clutter) are required at these wavelengths to identify unique target signatures and ascertain their detectability above ambient clutter from naturally occurring scatterers. Having a common platform in which multiple mmw wavebands and polarizations (both co- and cross-aligned) may be measured would allow a direct comparison of the BRDFs and the identification of unique signatures. BRDF measurements can take hours to days to acquire, placing severe stability and reproducibility requirements on both the heterodyne transmit/receive (Tx/Rx) hardware and the gonioreflectometer. The rapid maturation of heterodyne mmw Tx/Rx modules has made it possible for such long-term measurements to be performed, and verifiably accurate imaging techniques developed in other spectral regions may be adapted for alternative approaches to mechanical scanning by a gonioreflectometer. The deliverable will be a working gonioreflectometer-mounted heterodyne Tx/Rx system (or equivalent) configurable for mono-static or bi-static measurements, plus an analysis package that can autonomously obtain the four-dimensional polarimetric BRDF of test objects at least 30 cm x 30 cm x 30 cm in size in each of the following wavebands: Ka-band (35 GHz), V-band (60 GHz), W-band (94 GHz), D-Band (140 GHz), and G-band (220 GHz). The instrument, which will be delivered to AMRDEC at the end of Phase II, must measure and analyze BRDFs in a large (nominally 20’ x 20’ x 20’) anechoic chamber in a manner that can constrain or validate increasingly sophisticated models of RADAR cross sections for each waveband and polarization combination.

PHASE I: Demonstrate the feasibility of this concept by designing an instrument that can measure the mmw polarimetric BRDF of test objects at least 30 cm x 30 cm x 30 cm in size for at least a week of continuous operation. The heterodyne Tx/Rx module mounted on the gonioreflectometer or equivalent instrument must coherently measure amplitude and phase information and construct a BRDF with user-specified angular precision in each of the following mmw bands: Ka-band (35 GHz), V-band (60 GHz), W-band (94 GHz), D-Band (140 GHz), and G-band (220 GHz). An ideal instrument will require only trivial modifications to change operating waveband and

polarization so comparative BRDF measurements may be easily made. The Phase I deliverable is a detailed construction plan with performance estimates based on specified, available hardware with the required stability, power, and sensitivity to maximize signal to noise ratio (SNR) and minimize dwell time at each angle.

PHASE II: Using this plan, construct and demonstrate a prototype instrument that can measure the mmw polarimetric BRDF of test objects at least 30 cm x 30 cm x 30 cm in size for at least a week of continuous operation. The heterodyne Tx/Rx module mounted on the gonioreflectometer or equivalent instrument must coherently measure amplitude and phase information and construct a BRDF with user-specified angular precision in each of the following mmw bands: Ka-band (35 GHz), V-band (60 GHz), W-band (94 GHz), D-Band (140 GHz), and G-band (220 GHz). An ideal instrument will require only trivial modifications to change operating waveband and polarization so comparative BRDF measurements may be easily made. The Phase II prototype will have the required stability, power, and sensitivity to maximize SNR and minimize dwell time at each angle. It will also have a user-friendly analysis and graphical user interface to render the BRDF in a variety of user-specified formats that facilitate comparative analyses as a function of angle, waveband, and polarization. The prototype will be delivered to AMRDEC by the end of Phase II.

PHASE III: Dual Use Application: Expand the prototype into a fully functioning instrument that may estimate the RCS of larger military or civilian targets in the presence of ambient clutter. Millimeter wave RCS measurements will prove very useful in the growing need for remote detection of concealed anti-personnel terrorist threats in civilian venues like airports, courthouses, stadiums, and other large public gatherings. The value of an instrument for measuring the mmw BRDF is that it can help identify new methodologies (e.g. polarimetric, multispectral) for detecting such threats with greater reliability and a lower false detection rate.

REFERENCES:
1) K.B. Cooper et al., IEEE Microwave and Wireless Components Letters, Vol. 18, p. 64 (2008). K.B. Cooper et al., IEEE Transactions on Microwave Theory and Techniques, Vol. 56, p. 2771 (2008).

2) W.L. Chan et al., Reports on Progress in Physics, Vol. 70, p. 1325 (2007). W.L. Chan et al., Applied Physics Letters, Vol. 93, p. 121105 (2008).

3) B. Gorshunov et al., International Journal of Infrared and Millimeter Waves, Vol. 26, p. 1217 (2005).

4) J.C. Dickinson et al., Terahertz for Military and Security Applications IV, Proc. Of SPIE, Vol. 6212, p. 62120Q-1 (2006).

5) A. Semenov et al., Terahertz for Military and Security Applications VI, Proc. Of SPIE, Vol. 6949, p. 694902-1 (2006).

6) http://www.saic.com/products/software/xpatch/

7) Yasuhiro Mukaigawa et al., "Rapid BRDF Measurement Using an Ellipsoidal Mirror and a Projector" IPSJ Transactions on Computer Vision and Applications, Vol. 1, 21-32 (Jan. 2009).

KEYWORDS: millimeter wave, RADAR cross section, BRDF (bidirectional reflectance distribution function)

A12-106 TITLE: Bio-Inspired Processor

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: To research and develop an innovative, programmable, low-power, neuromorphic parallel processor that functions with power comparable to that of the biological neuron that is 1000 times more power efficient than popular processors available today.

DESCRIPTION: The US Army ARDEC is in search of a novel means to address the urgent need for a low-power parallel processor with functionality similar to that of the biological neuron to facilitate massive computational resources necessary to support un-manned aerial systems (UAS) applications, such as digital imaging, acoustic

processing, and other power intensive applications. This technology can reduce the cost of precision munitions by providing in-flight and terminal guidance. Standard systems have demonstrated that their ability to process and integrate data from various modalities is insufficient to provide valuable information judiciously. In addition, power constraints are often a restrictive factor when considering deployment in theater. Due to the limitations of conventional processor technologies, there is a critical necessity for a fundamentally unique processor in which the goal is to supply adequate computational capability with optimal and acceptable power requirements. The goal of this effort will be to design a parallel processor based on the neuromorphic characteristics of the biological neuron. Leveraging the efficiency of the human brain, based on numerous electro-chemical mechanisms and neuronal activity, provides an innovative methodology for logic interpretation and the transmission of signals.

Considerable investigation has gone into the modeling and simulation of the human brain and its neuronal components. This has led to the development of hardware configurations that can emulate neuronal behavior and functionality called neuromorphic architectures. Understanding the various components in these architectures has allowed for the development of complex simulations in software as well as small-scale, prototype integrated circuits. A predominant amount of this work has been performed to comprehend neuronal operation rather than prioritizing the application of neuromorphic concepts for a utilizable processor with favorable size, weight and power attributes. To accurately emulate the cellular neuron and all its intricacies it will be necessary to incorporate a mixed-mode element to accurately implement the integration of signals as in the neurons within the brain. These elements should consist of several individual neurons with the ability for their interconnections to be reconfigured dynamically. To augment processing capabilities and decrease power necessity, the internal network should be able to execute in parallel with the potential for the sub-units to be interconnected and networked for dedicated applications, as in the brain.

PHASE I: In Phase I, the contractor shall create one or more innovative and practical designs that leverages various neuromorphic research and development efforts to develop a technical approach for a low-power neuromorphic parallel processor. The technical approach should include the various bio-inspired components included within the proposed neuromorphic design as well as how these elements will implemented in a prototype solution. The proposed approach must demonstrate the ability for numerous neurons to operate simultaneously in parallel or/and in series with a timely data flow between the neurons and outside stimuli. In addition, details should be provided on the dual analog/digital capabilities of the neuron as well as the ability to reprogram interconnections (synapses) dynamically. Phase I should present a fundamental advancement in processor technology and provide a framework for which consequent phases can be supported. Deliverable of Phase I should be a paper study demonstrating feasibility of concept.

PHASE II: Phase II will consist of a complete prototype neuromorphic architecture design, simulation to ensure communication and system design functions properly, and a manufactured hardware chip with the appropriate semiconductor technology based upon the selected architecture. The neuromorphic design should be equivalent to the processing power of fifty million neurons in a package that weighs less than thirty grams, occupies less than fifteen cubic centimeters, and operates on less than two pico-Joules per operation. Current state-of-the-art neuromorphic processors utilize slightly under 1 watt per 1 million neurons on a compact, portable device. IBMs BlueGene project simulates in software 1.6 billion neurons and 8.87 trillion synapses with the C2 cortical supercomputer. The neuromorphic processor must be fully programmable through self or guided learning. The memory, i.e., synaptic junctions, should be greater than one hundred per neuron. The devise should be interfaced to a laptop for programming, control, and graphical user interface. Prior to fabrication, the full up prototype design shall be thoroughly evaluated through computer simulation of all components and their integrated whole to provide the highest level of confidence that the prototype will function as a neuromorphic system. The simulations shall include execution of multiple types of mathematical and logic algorithms, self learning, that is, self adjustment of synaptic strengths based on changes in outside stimuli, and power off with full recovery to the learned state prior to power off. Multiple simulations should be executed in which the processor correctly identifies hundreds of graphical structures where the outside stimuli is equivalent to that which would come from ten thousand rods in the human eye viewing those structures. Deliverable of Phase II should be a prototype of the neuromorphic system.

PHASE III: This technology will support many applications where computational requirements are severe while power consumption must be at the lowest possible level. Applicable mission related activities include surveillance, reconnaissance (ISR), automated target recognition and detection, IED detection, and acoustic processing. Commercial applications include any intensive processing applications such as imaging devices (hyperspectral imaging).

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KEYWORDS: neuromorphic, bio-inspired, processor, parallel processing, programmable, situational awareness

A12-107 TITLE: Rapid Analysis of Suspicious Powders

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: The objective of this topic is to develop an innovative technology that enables rapid, on-site screening of "suspicious powders" to determine if a biothreat agent is present and if so, its identity. The technology should also enable concurrent documentation of the sample.

DESCRIPTION: Since the mailing of Bacillus anthracis spores in 2001, there have been over 35,000 suspicious powder incidents reported in the US. Each incident causes disruption of activities at the scene of the event and costs tens to hundreds of man-hours before the area can be re-opened to the public. The expense of such a shut-down at some locations such as an airport could run into hundreds of thousands of dollars. Currently, first responders use hand-held laminar flow immunoassays (1, 2) or, much less often, PCR (3) for on-the-scene evaluation of suspicious powders to determine biological identification. These tests are costly; equipment to conduct the assays or evaluate the results can cost thousands of dollars, and each assay conducted costs an additional $15-$25 or more (2). Recent advances in highly sensitive label-free imaging of bacteria (4), lens-free microscopy (5), and micro-fluidics (6) techniques potentially offer new approaches to rapid screening of suspicious powders. Innovative, cost-effective methods are sought to conduct rapid, on-site screening of suspicious powders by first response personnel. The methods should be within the capabilities of response personnel without requiring advanced levels of expertise or extensive training.

PHASE I: As a proof of concept, a method will be developed that is able to rapidly determine if there are bacteria or bacterial spores present in a 10 milligram sample of suspicious powder that may be diluted by talcum powder or some other type of inorganic up to a mass ratio of 1000 inorganic to 1 biological. Specific identification of a bacterial biothreat agent or surrogate will be demonstrated within ~30 minutes.

PHASE II: An inexpensive (<$100) light-weight reusable hand-held prototype device will be developed that is capable of rapidly detecting and identifying at least 4 bacterial biothreat agents from the CDC Category A Bioterrorism Agents List, and at least one biotoxin. Consumables shall cost less than $1 per assay. The device will enable documentation of results obtained from each sample analyzed and rapid, simple reach-back capabilities. A system that also has the potential to detect viruses is a plus.

PHASE III: Development of a simple pre-processing step may be required to clean up environmental samples prior to loading into the device produced in Phase II. The resulting system must be usable by first responders and military personnel in full chem/bio protection gear.

PHASE III DUAL USE APPLICATIONS: Civilian and military first responders; derivative versions of this technology could be used by point of care clinicians for rapid diagnosis of infectious organisms.

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KEYWORDS: hand-held assay, biowarfare agent assay, biothreat, powder.

A12-108 TITLE: Ultra-Sensitive, Room-Temperature, Mechanical-Optical-Cavity Detectors for Long-Wavelength Applications

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: To develop and demonstrate an ultra-sensitive, room-temperature, long-wavelength detector that utilizes the coupling between a combined mechanical-optical-cavity system at the micro-to-nanoscale to achieve operational performance that exceeds the state-of-the-art in the Far-IR and THz regions.

DESCRIPTION: Optical forces are known to produce significant mechanical effects in micro- and nano-optomechanical systems [1-5]. Such interactions have been proposed as a means of constructing novel optomechanical components [6], such as tunable filters, couplers and lasers. Additionally, the static and dynamical manifestations of the coupling between the mechanical and optical degrees of freedom [1, 2] in such systems have been exploited in the development of electromechanical oscillators, tunable filters and switches, in enhancing the sensitivity of gravitational wave detectors, and in the study of the quantum dynamical properties of both light and mechanical systems. Therefore, the inherent physical advantages of light-based interactions with very small mechanical systems suggest basic paradigms for detectors that should be able offer very high detection sensitivities across very broad electrical bandwidths at the long wavelength end of the spectrum, e.g., far-infrared (Far-IR) and even beyond to terahertz (THz) regime.

Indeed, prior investigations [3-5] have demonstrated the basic advantages of using the available radiation pressure to affect the static and dynamical behavior of very high quality (Q) factor mechanical systems. These observations are very important because detection devices of this type are inherently optical, thereby being free of electrical interference. Furthermore, micro-to-nano size systems have the inherent potential for producing extremely high sensitivity at room temperature, and they can be tailored to operate at long wavelengths. Most importantly, the combined results of recent studies [6-8] indicate that electromagnetic (EM) field driven changes in mechanical resonators can be efficiently sensed by monitoring their influence on optical modes of a combined mechanical-optical-resonator system. Specifically, schemes employing the use of Whisper Gallery Mode (WGM) resonators

have achieved Q-factors of 10**11 [7] under laboratory conditions and 10**8 in practical devices [8]. Hence, these micro-scale resonator systems have already demonstrated minimum detectable powers (or temperature changes) on the order of 10**-9 watts (or 10**-4 K) [6-8].

These breakthroughs, and technical observations noted above, are already significant when compared the existing state-of-the-art. Presently, bolometric and pyroelectric sensors are the two leading classes of Far-IR and THz radiation detectors. However, bolometric sensors require liquid helium temperature operation in order to achieve the level of sensitivity of interest, so that they are cumbersome to use and therefore of no interest for comparison at room temperature. Conversely, pyroelectric sensors do operate at room temperature and they have high sensitivity at room temperature (micro-to-nanoscale watt level in the range 0.1 to 30 THz) but they are inherently electrical which means they are prone to noise problems, and they have a non-linear temperature coefficient which is problematic. All these facts strongly motivate further research into EM-field-driven mechanical-optical coupled cavities, which employ for example the response of WGM resonances [6] to incident radiation, for the purpose of realizing ultra-sensitive room-temperature detectors for application at the Far-IR and THz regimes. In addition, the research should be extended into mechanical-optical-cavity (MOC) detectors that employ external modulation of the incident radiation field and that utilize novel materials for optimizing the sensor time constant because these measures [8, 9] could lead to a ten times improvement in the room temperature sensitivity at very long wavelengths. As these ultra-sensitive, room-temperature, MOC detectors would offer significant potential for enhancing the operation of many Far-IR sensing systems of relevance to the military and it could open new opportunities for fundamental research into Far-IR and THz sensing science and micro-to-nanoscale phenomenology, a new research and development program is proposed. One particular scientific area of importance to the Joint Chemical and Biological Defense Program is the interaction of THz radiation with biological systems which could provide new methods for detecting hazardous organisms. These interactions may also prove useful in new methods of medical diagnosis. Hence, the associated long wavelength technological investigations would have significant relevance to biological and medical science.

PHASE I: Studies will be executed to explore the use of novel mechanical-optical-cavity (MOC) structures consisting of various geometries and materials to determine their potential for detecting long wavelength (Far-IR and/or THz regimes) radiation with very high sensitivity performance. This work will include physical modeling of the coupling between MOC elements and design simulations to optimize specific MOC structures and operational modalities. The Phase I effort should include fabrication experiments and optical and/or mechanical benchmarking testing that will demonstrate the general potential for the future implementation of an ultra-sensitive, room-temperature detector for operation with the Far-IR and/or THz regimes. The merit of the project will also be increased by defining micro-to-nanoscale phenomenology experiments that have potential for discovery in regards to long wavelength radiation and biological systems.

PHASE II: A prototype Mechanical-Optical-Cavity (MOC) detector will be developed that demonstrates ultra-sensitive, room-temperature performance that exceeds the state-of-the-art at long wavelengths (Far-IR and/or THz regimes). The expected technology development work should include but is not necessarily limited to: systematic studies of the MOC detector characteristics as a function of the structural parameters of the combined mechanical and optical resonators; detailed investigations into the use of various types of materials and coatings; development and implementation of a fully operational integrated detector platform with heat sinks, fibers and/or waveguide based optical coupling; and investigation into robustness and reliability issues in the context of a field sensor. The merit of the project will also be increased if micro-to-nanoscale sensing phenomenology research is performed to investigate the use of the technology for interfacing to, and interrogating, biological systems.

PHASE III: Refine the sensitivity and functionality of a new type of Mechanical-Optical-Cavity (MOC) detector concept, and design fabrication and integration procedures for defining a robust and reliable field sensor. The base technology would have direct applicability to point detection and standoff scanning imaging systems. The Phase III development work could also be expanded to perfecting the optical signal interface and to defining integration methods for potentially implementing the technology into focal plane arrays. Therefore, this new detector technology will have commercialization opportunities for such military relevant applications as detection of BW agents with obvious extensions to chemical and explosive threats.

PHASE III DUAL USE APPLICATIONS: This technology is relevant to scientific studies on the interaction of micro-to-nanoscale MEC systems with biological (and possibly chemical and explosive) targets. Hence, the technology work conducted in conjunction with this project could find applicability in many sensing areas, and especially in areas related to biological and medical science.

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KEYWORDS: long-wavelength, far-infrared, terahertz, mechanical-optical coupled cavities, detector

A12-109 TITLE: A Real-Time, Non-Invasive Monitoring System to Guide Accurate Fluid Resuscitation of Combat Casualties During Pre-Hospital and Transport Medical Care

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop an advanced decision-support medical monitor driven by algorithms that provide real-time processing of physiologic signals for the purpose of guiding accurate fluid resuscitation in humans who are hypovolemic due to hemorrhaging. The algorithm will run in real time on a resource constrained portable device.

The final device should provide a wireless connection between the patient and monitor, and the system should be capable of monitoring multiple patients simultaneously as well as forwarding clinical data to a central location.

DESCRIPTION: Emergency medical treatment is imperative when time and distance limit quick casualty evacuation. Early intervention during the "golden hour" (the first 60 minutes following a traumatic injury) has long been recognized by medical personnel as vital to saving lives. Since hemorrhagic shock remains a leading cause of death on the battlefield (1), it is critical to provide medics with real time monitoring of soldiers with traumatic injuries and real-time fluid resuscitation support. Current fluid resuscitation strategies are based on standard vital signs, including blood pressure, heart rate and arterial saturation. We know from experience, however, that humans are unable to recognize subtle changes in these parameters until late in the course of ongoing blood loss (2-4). Inadequate resuscitation poses the risk of inadequate tissue perfusion and end organ damage. Conversely, overly aggressive fluid resuscitation may result in hemodilution of clotting factors resulting in coagulopathy (5,6), or elevated arterial blood pressure that can dislodge clots from vascular injuries (6), resulting in further blood loss and possibly death. How to best proceed when one is dealing with a multiple-injured patient who has a traumatic brain injury and exsanguinating hemorrhage can be especially difficult. A small portable device is needed that continuously evaluates an injured soldier's hemodynamic status in a beat-to-beat fashion and periodically updates or alerts a medic if a change in the injured soldier's clinical status is detected or an adjustment in IV fluid therapy is warranted.

PHASE I: Demonstration of a proof-of-concept algorithm to provide moment-to-moment integration of standard vital signs or other novel physiological signals capable of tracking hemodynamic compensations due to alterations of central blood volume in humans during fluid resuscitation. Contractors should explore novel approaches for the analysis of physiological signals which can lead to the development an effective plan for real-time implementation. In Phase I, the algorithm will process, in near real time, continuous physiological signals related to alterations in central blood volume. The contractor is encouraged to explore novel physical signals, with the understanding that current non-invasive physiological signals such as the electrocardiogram (ECG), photoplethysmogram (PPG), oxygen saturation (SpO2), respiratory measures and blood pressure (BP) may provide a good starting point to derive the necessary physiological information. The algorithm will process one or more of the individual physiological signals and extract the necessary parameters to robustly determine the circulating blood volume status of an individual patient and how that individual is responding to fluid resuscitation. In order to accomplish this objective, the use of machine-learning techniques to implement the algorithm is encouraged. The successful algorithm will be required to process noisy physiological signals, while still maintaining robust performance in tracking fluid resuscitation during hemorrhaging. The contractor will be given access to a progressive hypovolemia data set produced at the US Army Institute for Surgical Research. Contractors are also encouraged to use other data sets relevant for the development of their fluid resuscitation algorithm.

PHASE II: The contractor will further develop and optimize the resuscitation algorithm across various data sets. Optimization of the algorithm should utilize both simulated and actual trauma patient data. The contractor will integrate the algorithm software for tracking changes in central blood volume (i.e., hemorrhage severity detection and accurate resuscitation) in a real-time portable device. The device will display and archive the collected data. The device will be tested with both actual and simulated data sets. Evaluations of the system will encompass: data quality, real-time operation, performance measures, robustness, and consistency.

PHASE III: The contractor will produce a working device capable of providing beat-to-beat real-time fluid resuscitation decision support to assist combat and civilian medics in fluid management and triage prioritization. The device should provide a wireless connection between the patient and monitor, and also be capable of monitoring multiple patients simultaneously. The final device must provide IEEE compliant wireless and a physical connector to allow connection to individual computers and computer networks. Such a device could save lives by providing critical information on hemorrhage, fluid resuscitation and triage priority. The device should be of great commercial interest for all branches of the U.S. armed services as well as pre-hospital and trauma centers around the world.

The final device must provide IEEE compliant wireless and a physical connector to allow connection to individual computers and computer networks. Such a device could save lives by providing critical information on hemorrhage severity, and should be of great commercial interest for all branches of the U.S. armed services as well as civilian critical care professionals working in the pre-hospital transport setting and trauma centers around the world.

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KEYWORDS: fluid resuscitation monitoring, medical monitors, clinical decision-support, trauma, hemorrhagic shock, machine learning algorithms, vital signs

A12-110 TITLE: Local Active Noise Reduction for MEDEVAC and CASEVAC

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop a litter-mountable active noise-reduction system that will reduce the level of noise in a Black Hawk MEDEVAC or CASEVAC helicopter to 80 A-weighted decibels (dBA) at the casualty's head without interfering with monitoring of the casualty's condition or with in-transport medical treatment.

DESCRIPTION: Medical evacuation of ill, injured, or wounded Soldiers often occurs in air and ground vehicle with very high noise levels in the compartment in which the casualty is being transported. For example, the sound levels in the right center position in the cabin of the UH-60A Black Hawk helicopter flying at 120 knots with doors open are recorded at 106 A-weighted decibels (dBA). In accordance with Army regulations and the operator's manual (i.e., the "dash 10") of the UH-60A aircraft, all Army aircrew are required to wear both earplugs and the sound-protective flight helmet (HGU-56/P Aircrew Integrated Helmet System) in this environment. If a casualty has suffered a head injury, it is unlikely that traditional head-borne or insert hearing protection devices could be used, even if they were available. In this environment, a casualty without hearing protection exceeds his/her 100% noise dose in less than four minutes. Thus, it should be readily apparent that a casualty being transported in a vehicle with these noise levels will be at significant additional risk for permanent hearing injuries.

However, the risk of hearing injury is not the only problem that excessive noise causes in the MEDEVAC environment. The noise levels in an Army MEDEVAC helicopter will completely eliminate the possibility of communication between the casualty and medical personnel, thus negatively affecting treatment. Furthermore, physiological stress responses are evoked by noise levels significantly lower than either experienced in the MEDEVAC environment or even the "safe" levels promulgated by industrial hearing conservation regulations (Babisch, 2002, 2003). This added stress may significantly impair the recovery of the ill, injured, or wounded patient (McCarthy, Ouimet, & Daun, 1991).

The principles of active noise reduction (ANR) or active noise control are well known (Hansen, 2001; North Atlantic Treaty Organization, Research and Technology Organization, Human Factors and Medicine Panel, 2005). Using feed-forward (predictive), feedback, or hybrid techniques, an ANR system produces a sound ("anti-noise") whose compression and rarefaction phases are intended to cancel the rarefaction and compression phases of unwanted noise in a space, an earcup, or underneath an earplug. The proposed system will significantly reduce the

noise exposure to the casualty being transported with consequent reduction in environmental stress that adversely affects the casualty as well as the risk of permanent hearing loss from excessive noise.

PHASE I: Develop an initial concept design and model key elements for an active noise reduction system, mountable on a standard NATO litter, that will reduce noise at patient ear locations to less than 90 dBA in the presence of pink noise presented at 106 dB sound pressure level (SPL). Identify the key elements required for airworthiness testing for use in US Army MEDEVAC and CASEVAC operations.

PHASE II: Based on Phase I results, construct and demonstrate the operation of a prototype MEDEVAC ANR system that will reduce the noise at ear locations to less than 80 dBA in the presence of pink noise presented at 106 dB sound pressure level (SPL). Demonstrate that the prototype system can pass the stringent requirements for airworthiness certification for medical devices by the US Army Medical Command.

PHASE III: Medical evacuation in air or ground vehicles often includes an environment in which the presence of noise will interfere with patient assessment, triage, and treatment, produces additional stress on the patient and medical personnel, and may comprise a significant risk of permanent hearing losses and/or tinnitus. Road noise, engine and drive train noise, rotor noise all compromise the medical care given to the ill, injured, or wounded. The development and deployment of a local active noise generation system for air or ground ambulances should significantly improve the quality of care given during the “golden hour” following injury or wounding.

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KEYWORDS: medical evacuation, MEDEVAC, CASEVAC, noise, active noise reduction, stress reduction

A12-111 TITLE: HCI and C2 for Autonomous Air Evacuation of Casualties

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To investigate, propose and demonstrate prototype technical solutions addressing key elements of autonomous vertical takeoff and landing (VTOL) unmanned aircraft systems (UAS) for medical missions such as critical item resupply and casualty evacuation (CASEVAC). Specifically, to design and demonstrate prototype human computer interaction (HCI) and command and control (C2) subsystems for medical resupply and CASEVAC missions.

DESCRIPTION: This topic is intended to incrementally advance the state-of-the art in autonomous VTOL UAS capability for critical medical item resupply and CASEVAC. This topic will develop and demonstrate in an operationally relevant environment; a feasible, viable and appropriate HCI architecture and implementation for the C2 of a VTOL UAS by an untrained or minimally trained corpsman or medic in a tactical environment (i.e., between first responder and Role 1 facility).

This topic will also develop and demonstrate in an operationally relevant environment; a VTOL UAS C2 architecture and a Medical C2 architecture based on current or planned actual architectures (both Army and Marine Corps).

Demonstrations should include actual HCI and C2 components (i.e., computers, tablets, smart phones, radios and data links). Further, targeted VTOL UAS platforms should be full-sized, man-rated (preferred) VTOL UAS, preferably one in the current or DoD inventory (e.g., Boeing Little Bird, Kaman K-Max, Boeing A-160 Hummingbird); or a potential future platform such as the Sikorsky Blackhawk /Seahawk, Northrop Grumman Fire-X UAS (Bell 407); and EADS Lakota optionally piloted helicopters, and the Urban Aeronautics AirMule).

Fielding this capability will speed and enhance the evacuation and subsequent treatment of casualties, both in a military and civilian environment.

Note 1: Per Army Medical Department (AMEDD) Policy, further research and development of autonomous casualty evacuation (CASEVAC) is warranted and directed.

Note 2: Demonstration using actual VTOL UAS is not required, but a specific platform(s) must be identified and its specific HCI and C2 architecture and components utilized.

PHASE I: Develop the conceptual models, functional requirements, and component architectures for the HCI and C2 tasks described above. Identify preliminary targeted VTOL UAS and related HCI and C2 interfaces and components, and address both air vehicle C2 and Medical C2. Demonstrate models and the architecture implementation in a simulated (M&S) environment, or with actual components, in a laboratory environment. Begin developing a realistic commercialization plan.

DELIVERABLES:
(1) Conceptual models (document),
(2) Functional requirements (document),
(3) 'Short list' of VTOL UAS candidates and related HCI and C2 components (document),
(4) Component architectures (document),
(5) Demonstrations of the conceptual models, architectures and candidate HCI and C2 components in M&S or laboratory environment (videos, documents),
(6) Draft commercialization plan,
(7) Phase I Final Report.

PHASE II: Downselect the target VTOL UAS and identify required HCI and C2 components. Continue and finalize the development of all conceptual models and functional requirements. Implement these models meeting the identified functional requirements, in actual hardware and software, and demonstrate an urgent medical resupply mission and a CAEVAC mission, in an operationally relevant environment using an untrained (in UAS operations) individual. The technology readiness level (TRL) goal for the end of Phase II is TRL-5. The commercialization plan should be further refined and largely completed.

DELIVERABLES:
(1) Specify target VTOL UAS platform (document),
(2) Final conceptual models and functional requirements (document and software),
(3) Concept of Operations or vignettes for medical resupply and CASEVAC missions to guide the technical demonstrations (documents),
(4) Demonstrate the HCI and C2 (UAS platform and Medical) for the medical item resupply and CASEVAC missions (demonstrations, videos, documents),
(5) Final commercialization plan (document),
(6) Phase II final report (document).

PHASE III: Further develop these capabilities to TRL-7 or 8. Assist the military in transitioning this autonomous VTOL UAS HCI and C2 technology to a Joint Capability Technology Demonstration, or other technology development or acquisition program(s). Once validated conceptually and technically, the dual use applications of this technology are significant in the area of civilian emergency services; this technology could potentially save many lives among military and civilian casualties and injured persons. Coordinate with civilian first responders and Homeland Security agencies to transition the capability to civilian first responders for emergency response in hazardous or contaminated environments or in remote medically underserved areas and eventually commercialize the system.

DELIVERABLES: Products (software, hardware, documentation) ready for commercialization and a military assessment in an operational environment.

REFERENCES:
1. Army Unmanned Systems Initial Capabilities Document, Aug 2010

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3. USMC VTOL UAS Air Cargo Assessment Report (from assessment currently underway in theater) – if available

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KEYWORDS: Unmanned Aircraft System, UAS, Unmanned Aerial Vehicle, UAV, autonomy, CASEVAC, human computer interaction, HCI, command and control, C2.

A12-112 TITLE: A New Generation of Actuators for Robotic Systems

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Design and prototype adaptive actuators for medical robotic systems to improve the robotic capacity needed for future medical robotic applications, such as heavy patient lifting, combat casualty evacuation, dexterous manipulation, and combat casualty care.

DESCRIPTION: Background. Today's robot systems have been evolving from industrial applications into human services. Robots are transferred from a caged or fenced application environment into a human co-existing world. Many service robotic systems have been built for supporting human interactions and servicing, such as rehabilitation robots, assistive robots, etc. The most important feature for the robots applied in the human world and with human interactions, is intrinsic safety built into the actuation. For a wide variety of applications robotic system designers have been facing challenges in developing robotic systems with necessary safe actuation, sufficient strength, desirable agility in response, and control accuracy and flexibility, for dexterous manipulation.

Adaptive actuation is highly desired for human centered interaction and applications, particularly when assistance and cooperative collaboration with variable payloads (e.g., gently touching and rolling combat casualty, applying emergency devices/tools for casualty treatment, heavy patient lifting, and actions for robot-nurse collaboration during patient care) is planned. Such adaptive robotic actuation must have compact, configurable hardware and embedded software and support human-robot interactions. So far, research on adjustable actuation is mainly focused on adaptive or adjustable actuation on biped locomotion control for interacting with an unstructured environment and energy efficient actuation. Although there are applications of compliant actuation in humanoid manipulation, there is none in 'adaptive' compliant actuation for robotic manipulation to date. The key requirements for developing such adaptive actuators are: (1) adjustable component parameters or structure, (2) precise force and strength control, (3) modular structure, (4) sufficient bandwidth for desirable dynamic response time, (5) intrinsic safe mechanism, and (6) effectiveness for dexterous manipulation and human-robot interactions.

Topic Description. In robotic applications such as patient lifting in a clinical setting, or casualty evacuation in a combat situation, very small actuators are required producing high torque yet consuming little power. A robotic nurse's assistant, for example, needs to perform a gentle pulling/rolling action to move a patient onto one side; as well as have brute-force power to lift and transport a heavy patient. On-the-other-hand, a combat medic may require a robotic system with dexterous manipulation capability to extract a casualty from a confined space and then brute-force power to lift and evacuate the casualty

Research to date has yet to solve these challenges. Robotic casualty extraction and evacuation research conducted or sponsored by the Army has yet to solve the challenges posed by safely picking up wounded soldiers. For evacuation of wounded from live fire zone dragging is preferred to lifting. However, grabbing soldier by his/her collar or harness and pulling them along requires the casualty care robotic system to have a haptic feedback capability in the end effectors. Significant research challenges remain in adapting, integrating, and developing new robotic actuator technologies to approach, safely pick-up and extract humans to safety where they can be triaged, treated and further evacuated by medical or other first responders.

PHASE I: Conduct research and collect data to determine the state-of–the-science in adjustable, compliant robotic actuation for medical robotic system applications in the areas of general healthcare, patient lifting, elderly care, combat casualty evacuation, dexterous manipulation, and humanoid robot operations. Provide a detailed report describing the conceptual design of adaptive actuators for healthcare, combat casualty care, patient lifting, combat casualty evacuation etc. Identify design features and design approaches that will improve the operational capacity for the above medical robotic applications. Deliver a proof-of-concept feasibility study of the design in Phase I. Subsystem or component brassboard or benchboard demonstrations are encouraged.

DELIVERABLES: (1) Determine state-of-the art for adjustable, compliant robotic actuation for the medical missions and tasks described above (document), (2) Conceptual design of a new adaptive actuator for the missions and tasks described above, and addressing current constraints and issues with existing actuators (document), (3) Proof-of-concept feasibility study supporting the conceptual design (document) and (4) Subsytem 'brassboard' demonstration desired (laboratory demonstration), (5) Initial commercialization plan (document).

PHASE II: Design, develop and demonstrate a functional prototype of such an adaptive actuator to enhance robotic operation capabilities for general healthcare, patient lifting, elderly care, combat casualty evacuation, dexterous manipulation, and humanoid robot operations. The anticipated types of payload to be investigated of this research are patient and casualty, but it is also desirable to maneuver lightweight payloads like medical devices/tools and other payloads such as improvised explosive devices (IEDs) and unexploded ordnances (UXOs).

The actuator hardware and embedded software should be able to cover all (preferred) or a subset of requirements listed below:
• Sufficient strength (desirable payload capacity of up to 400lbs and actuator toque of up to 800 Nm) for heavy patient lifting and combat casualty evacuation
• Sufficient range of motion for a desirable work space of robotic system (e.g., close to typical human kinematic specs)
• Sufficient bandwidth and effective dynamic response during dexterous manipulation (small force bandwidth of 50 Hz)
• Desirable power consumption for actuators should not be higher than 1 hp.
• Acceptable operation accuracy in casualty care and necessary treatments
• Adjustable parameters of actuation components during operation tasks when the payload varies
• Work safely and robustly with modular and compact design
• Work well for human-robot interactions and certain sensory perception
• Demonstrate better performance (size, weight, power consumed, force generated, etc.) than current actuators employed on robotic/UGV platforms such as: BEAR, cRoNA and Warrior
• Technology Readiness Level goal of TRL-4/5

DELIVERABLES: (1) Demonstration of a prototype actuator, including hardware and software, meeting the Phase II performance goals on a robot or unmanned ground vehicle (demonstration, videos, documents), (2) Robust and largely complete commercialization plan (document).

PHASE III: The ultimate goal of this research is to provide a new type of actuator for medical robot systems to enhance healthcare quality and improve combat casualty evacuation capabilities to save soldiers' lives. These adaptive actuators will also be applicable in service robots for warehouse merchandise handling, industrial production assembly line, search and rescue robots, fire fighter assistant robots, IED disposal robots, and numerous industrial robotic applications. Goal is TRL-7/8.

DELIVERABLES: (1) Products (software, hardware, documentation) ready for commercialization and a demonstration on a robot or unmanned ground vehicle in a realistic operational environment.

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3. USAMRMC TATRC Robotic Casualty Extraction and Evacuation Program:
http://www.tatrc.org/ports/robotics/docs/USAMRMC_CCC_CSS_Robotics.pdf

4. Sanjay Dastoor and Mark Cutkosky, Variable Impedance due to Electromechanical Coupling in Electroactive Polymer Actuators,
http://bdml.stanford.edu/pmwiki/uploads/Main/PerchingPublications/DastoorIROS11Preprint.pdf

5. Pieter Beyl, Bram Vanderborght, Ronald Van Ham, et al, Compliant Actuation in New Robotic Applications, http://lucy.vub.ac.be/publications/nctam06.pdf

6. Jakob Oblak and Zlatko Matjacc, Design of a series visco-elastic actuator for multi-purpose rehabilitation haptic device, Journal of Neuroengineering and Rehabilitation, 10:1186/1743-0003-8-3, January 20, 2011

7. Reza Ghorbani and Qiong Wu, Closed Loop Control of an Intentionally Adjustable Compliant Actuator, Proc. of the 2006 American Control Conference, Minneapolis, Minnesota, USA, June 14-16, 2006

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KEYWORDS: Robotics, compliant actuator, combat casualty evacuation, patient lifting, dexterous manipulation, humanoid robot.

A12-113 TITLE: Temperature-Controlled Transport Container for Packed Red Blood Cells

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop and demonstrate a materiel solution for a passive and thermally efficient temperature-controlled transport container (cold chain container) that has a service life of not less than 5 years without a need for normal repairs and maintenance. Identify method(s) to reduce or eliminate the need for preconditioning of the container.

DESCRIPTION: Delayed casualty evacuation from far-forward battle areas necessitates the need for medical personnel to carry small amounts of payload (packed red blood cells (pRBCs), etc.) far-forward on the battlefield. The extreme hot and cold temperatures make it difficult to store payload in containers with wet ice at the right refrigerated temperature for very long. To resolve this shortcoming, personnel utilize lightweight, insulated containers to carry up to 2 liters (L) of payload (approximately 10 pounds when full) at required refrigerated temperatures of 1-10 °C for up to approximately three days.

The current Army solution needs no power source (passive) to maintain its internal temperature. A combination of vacuum-insulated panels (VIPs) and phase-change material (PCM) maintains the refrigerated temperature. However, both the VIPs and PCM have limited effectiveness over time. Historically, VIPs have proven unreliable and original equipment manufacturers (OEMs) cannot guarantee efficacy beyond a two-year period. PCMs are subject to repeated thermal stress and will not consistently change phase at the appropriate temperature. No feedback is provided to the user regarding the suitability of the container for its next mission.

The current solution can also be utilized for other products that require temperature control during transport. However, limitations of preparation, reliability and shelf life persist in the current technology and must be reduced or eliminated.

PHASE I:
1. The materiel solution for a container shall have the following considerations:
a) Maintains temperature (1–10 °C) for 48+ hours (preferably 72+ hours) in any climate
i) Duration between 2–8 °C should be considered for pharmaceutical applications

b) Evaluate all containers at external temperatures of -27 °C and 40 °C for expected duration

c) Consider mass, volume, and portability
i) Device mass should not exceed 10 pounds (lbs) fully loaded
ii) Device volume should not exceed 0.5 cubic feet (ft3)
iii) Payload volume should be approximately 2 liters
iv) One-person 'hands-free' carry (ex: adjustable shoulder strap, belt or clip, etc.)

d) Minimize/Eliminate preconditioning (technology preparation)

e) Maximize/Eliminate useful life or shelf life.

2. Determine if unique container shapes (non-parallelepiped), such as cylinders or spheres can be realized. These shapes can eliminate or minimize edge heat losses of VIP applications. This is a particular concern when the seam length and surface area are of similar magnitude. Edge heat losses of VIP applications can be much higher than those of the VIP itself.

3. Determine through vendor research and current literature if VIP reliability may be extended beyond two years through good manufacturing practice (GMP) or empirical data.

At the conclusion of this phase, the contractor will develop an initial concept design and model key elements, including but not limited to thermal simulation, weight and cube.

The contractor will also provide a white paper not to exceed 2 pages regarding VIP reliability as stated in bullet 3.

PHASE II: Transition the Phase I concept(s) into six (6) prototypes delivered ready for temperature control testing. These prototypes will be of the best quality that can be produced with the design considerations specified for 1-2 of Phase I. Suggestions for constant monitoring of internal temperature of the container during transport.

VIP evaluation (point 3 of Phase I) of reliability versus shelf-life will continue with literature updates and the acquisition of any additional empirical data.

At the conclusion of this phase, the contractor will have produced six (6) prototypes that successfully pass temperature control testing. In addition, the contractor will provide:
1. Options (3 minimum) that will constantly monitor the internal temperature of the container with high reliability and minimal power requirements
2. An analysis of current OEM VIPs (if viable) as a candidate for the shelf life extension program (SLEP).

PHASE III: Focus on commercialization and technology development. Explore tailoring to user needs (fit and form) and system integration. Address and assess additional test requirements, such as MIL-STD-810.

The usefulness of the technology developed under this SBIR can benefit all military medical centers worldwide, especially those in far-forward areas. The feasibility of this container for temperature-controlled supply chain transport is expected to extend to other biologics (e.g., vaccines, organs, etc.) and non-biologics requiring transport in the desired temperature range (2–8 °C). We envision that the contractor that develops reusable and reliable technology can become a market driver in transfers of longer than 1 day in the commercial sector. This includes a majority of the Third World, where vaccines and medical assistance are in high demand and short supply. The temperature-controlled supply logistics community is moving to highly reliable, reusable containers. These efforts have shown to be cost effective and provide significant risk reduction.

At conclusion of this phase, the contractor will provide:
1. No fewer than 10 preproduction articles for technical testing and demonstration in an operational environment.
2. A commercial transition plan, including projections for the implementation for similar containers of larger scales (payload volume) and contents (biologics, etc.)
3. A detailed plan for life-cycle (logistics) analysis and routine validation of the design

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KEYWORDS: Cold chain, Packed Red Blood Cells, Vacuum insulated panels, Casualty evacuation, Temperature management, Packaging solutions, Temperature monitoring, shelf life extension program

A12-114 TITLE: Automated, Enroute Combat Casualty Care

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Per Army Medical Department Policy (AMEDD), adequate enroute care is required for casualty evacuation conducted on non-MEDEVAC vehicles. Likewise, AMEDD policy prohibits unattended casualty evacuation on unmanned vehicles without enroute care capabilities normally provided by human attendants. The objective of this topic is to develop and demonstrate a handheld prototype system of systems that incrementally advances the state of the art in enroute combat casualty care assessment, monitoring, and intervention on attended casualty evacuation vehicles such that the final demonstration shows proof-of-concept feasibility for future casualty evacuation on unmanned vehicles.

DESCRIPTION: This topic is designed to focus and address a wide-range of technical challenges in medical monitoring and intervention; information capture, storage and security; and communications integration with both civilian and military networks that requires a new direction in design and integration research. It is now technically possible and operationally feasible to combine most of the physiological monitoring, medical information exchange, imaging, and telemedicine technologies that are now in use, undergoing evaluation, or still in development; with emerging semi-autonomous, autonomous, or closed-loop treatment and intervention systems. In the past, DARPA worked on a project with this aim called the “Trauma Pod Program”. It was overwhelmed by a host of technical and operational research challenges which were, at the time, infeasible to overcome. This topic focuses down to a

capability that can be used on any vehicle instead of DARPA's wide range of initiatives; these specific areas are: 1) Providing functional medical assessment, monitoring, or intervention application system modules that minimize size, weight, power consumption, and can be fit inside and run on host tactical medical ground vehicle or aircraft platforms; 2) Enabling within the same space, weight, and power constraints, either autonomous closed loop operation or securing access to sufficient bandwidth on the battlefield to enable tele-operated semi-autonomous operation, command and control on the move; 3) ruggedizing for shock, dust, sand, and water resistance to enable reliable, uninterrupted operation in combat vehicles on the move, to include operation and storage at extreme temperatures, and EMP hardening.

The intent of this topic is to undertake research; aimed at developing a prototype capability that within said constraints which will integrate and incrementally advance the state of the art in enroute combat casualty care communications and automation of combat casualty assessment, monitoring, and intervention on attended casualty evacuation vehicles; such that the final demonstration will show a proof-of-concept feasibility for future casualty evacuation on unmanned vehicles. Size and weight are important factors; ultimate object of the medic attended system would be secure wireless connections between patient continuous medical monitoring sensors and military tactical radios to a handheld integrated processor, display, and communications device similar in size and weight to a mobile phone such that a soldier/medic could carry the device in a uniform pocket. Quantitative values for acceptable operational and storage temperatures and power requirements should be planned to comply with applicable MIL-SPECs (available on line). To facilitate commercialization the hand-held device should incorporate embedded capabilities for connecting to both military common-user tactical radio networks and ubiquitous civilian communications networks.

PHASE I: Research solutions for technical challenges on this topic as identified above for a capability that incorporates feasible solutions: physiological monitoring and telemetry; medical information exchange and analysis; imaging; and in semi-autonomous, autonomous, or closed-loop treatment. The intervention system should be designed as a ruggedized handheld prototype that integrates and will incrementally advance state of the art in enroute combat casualty care communications and automate combat casualty assessment, monitoring, and intervention on attended casualty evacuation vehicles. A final demonstration, after Phase II, will show proof-of-concept feasibility for future casualty evacuation on unmanned vehicles. Develop a Phase II proposal incorporating the proposed design into a work plan. Flesh out commercialization plans that were developed in the Phase I proposal for elaboration or modification to be incorporated in the Phase II proposal. Explore commercialization potential with civilian emergency medical service systems development and manufacturing companies. Seek partnerships within government and private industry for transition and commercialization of the production version of the product within government and civilian health care systems involved in combat casualty care, internal development and disaster response, emergency medical services, wilderness medicine or health care in extreme environments where ruggedized medical support systems are needed.

PHASE II: From the Phase I design, develop a ruggedized handheld prototype system or system of systems to demonstrate incremental advances in enroute combat casualty care to include automation of casualty assessment, patient monitoring, and treatment intervention on attended casualty evacuation vehicles; such that the final demonstration shows proof-of-concept feasibility for future casualty evacuation on unmanned vehicles. In addition to demonstrating secure wireless connectivity to medical monitors and military tactical radios; the handheld device should demonstrate communications to ubiquitous civilian broadband wireless communications networks. The prototype should clearly demonstrate, for at least three prevalent combat casualty diagnoses: 1) integration; 2) feasible operation; and 3) semiautonomous or autonomous analysis, decision making, command, and control of subsystems for:
1) Physiological monitoring and telemetry
2) Diagnostic imaging
3) Treatment and intervention

Some examples of prevalent combat casualty diagnoses are loss or near loss of limb, blocked air way, sucking chest wound, internal bleeding, or traumatic brain injury. Demonstrate the system with soldier medical attendants in a relevant environment; such as at a USA Army TRADOC Battle Lab. Flesh out commercialization plans contained in the Phase II proposal for elaboration or modification in Phase III. Firm up collaborative relationships and establish agreements with military and civilian health care networks to conduct proof-of-concept clinical trials in Phase III. Begin to execute transition to Phase III commercialization potential in accordance with the Phase II commercialization plan.

PHASE III: Refine and execute the commercialization plan included in the Phase II Proposal. Execute proof-of-concept clinical trials as per research protocols developed during Phase II. Participate in appropriate advanced Warfighting experiments or Joint Capability Technology Demonstration(s) that demonstrate combat casualty care technologies. Present the prototype project, as a candidate for fielding, to applicable Army, Navy/Marine Corps, Air Force, Coast Guard, Department of Defense, Program Managers for Combat Casualty Care systems along with government and civilian program managers for emergency, remote, and wilderness medicine within state and civilian health care organizations, and the Departments of Justice, Homeland Security, Interior, and Veteran's Administration. Execute further commercialization and manufacturing through collaborative relationships with partners identified in Phase II.

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KEYWORDS: combat casualty care, automation, autonomy, artificial intelligence, combat medic, telemedicine, medical informatics, mobile device, cell phone, ultra wideband radio

A12-115 TITLE: Rapid Extraction of Arthropod Nucleic Acids for Diagnostic Testing

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: To develop a system that has high-throughput capability for extracting nucleic acids from arthropods, to include ticks, mosquitoes, and sand flies. The system must then be able to deposit purified nucleic acids into multiple type of receiver (i.e., tubes or plates) for future diagnostic testing systems.

DESCRIPTION: The rapid identification of relevant arthropod transmitted pathogens and the determination of potential human disease risk, especially in hostile environments, is of great importance to the U.S. military. In some cases, determining if a given pathogen is present in a given area is important for emphasizing the level of personal protective equipment (PPE) or personal protective measures (PPM) necessary for a given area. To determine if an arthropod-borne pathogen is present in a given area, hundreds (and even thousands) of pools of arthropods (a pool of arthropods contains one to 25 specimens) would need to be screened in order to conduct risk assessments for that given area. The screening of large numbers of arthropods is necessary to determine the infection rate, and thus the risk from acquiring an infection from the bite of an arthropod.

Currently, vector surveillance is conducted by manually pooling and processing thousands arthropods for subsequent testing. To alleviate this bottleneck, a system that has high-throughput capability for extracting nucleic acids from arthropods (to include ticks, mosquitoes, and sand flies), followed by automated sample preparation would help alleviate this issue. The system must then be able to deposit purified nucleic acids into multiple type of receiver (i.e., microcentrifuge/PCR tubes, real-time PCR capillaries, or 96-well plates) for current and future diagnostic testing systems. The development of a processing/purification system would enable Preventive Medicine Units to screen more arthropods for more pathogens in less time and with less logistical needs, thus resulting in better vector surveillance, diagnostic testing, and risk assessments.

Requirement: To extract nucleic acids from arthropods in a high-throughput manner for diagnostic applications using arthropods collected during military deployments. The unit/system would need to be fieldable, with minimal logistical requirements, and should be designed for far forward applications in a deployed setting.

Desired Capability/Concept of Final Product: The primary vision for the final product would be a unit/system that would sit on a regular laboratory bench (or smaller in size) where the investigator would load pools of arthropods into it using the developer's designated tubes or plates. The arthropods would consist of soft-bodied arthropods (e.g., mosquitoes, sand flies, and swollen blood-filled ticks) or hard-bodied arthropods (e.g., adult hard ticks). The unit would then process the arthropods and would produce purified nucleic acids that would then be deposited into microcentrifuge tubes, real-time PCR capillary tubes, or 96-well plates for diagnostic testing. The diagnostic testing is not a part of this topic. The unit/system should be rapid, cost effective, and easy to use, with reagents that are stable at elevated temperatures for extended periods of time (e.g. 40oC for 2 years).

Technical Risk: There is a degree of technical risk associated with this project. Currently, there is no single unit/system that fulfills the requirements of this proposal. The candidate contractor is expected to use innovative and in-house or associated expertise to develop a prototype that meets the needs of the Department of Defense.

Access to Government Facilities and Supplies: The candidate contractor should coordinate with the Contracting Officer's Representative (COR) to determine if any support is available for supplying arthropods or other testing materials.

PHASE I: The selected contractor will determine the feasibility of the concept by developing a prototype unit/system where pools of arthropods are loaded into it using the developer's designated tubes or plates. The unit would then process the arthropods and would produce purified nucleic acids that would then be deposited into microcentrifuge tubes, real-time PCR capillary tubes, or 96-well plates for diagnostic testing. The unit/system should be rapid, cost effective, and easy to use, with reagents that are stable at elevated temperatures for extended periods of time (e.g. 40oC for 2 years). For Phase I, the prototype should be able to process up to 48 pools of arthropods in less than 4 hours and should be able to deliver purified nucleic acids into microcentrifuge/PCR tubes (Threshold). The contractor will conduct initial laboratory evaluations of the prototype device with both soft-bodied and hard-bodied arthropods and will supply a written report to the COR. By conclusion of Phase I, the contractor will provide a prototype unit/system to the COR for evaluation. The degree to which the prototype unit/system meets the desired capability as outlined above will be evaluated at a government laboratory. Data from this independent evaluation will be used in the determination of a Phase II awardee, if applicable.

PHASE II: The prototype unit/system should be able to process 960 pools of arthropods in less than 8 hours and should be able to deliver purified nucleic acids into microcentrifuge/PCR tubes, PCR capillaries, or 96-well plates (Objective) and should be fieldable. The prototype should consist of a single unit without the need for manual transfer of sample/material between the stages (Objective). The selected contractor will conduct comprehensive laboratory evaluations of the unit/system performance characteristics (to include, but is not limited to the number of arthropods in a single pool, reliability, ease of use, and range of usable work conditions, e.g., conducting the processing where the sun is shining on the work area and where the work is conducted at 35oC in a dusty environment). The selected contractor will also conduct stability testing of the unit/system/components/ associated reagents as part of Phase II. The stability testing should be conducted under both real-time and accelerated conditions (e.g. attempt to force the unit/system/ components/associated reagents to fail under a broad range of temperature and humidity conditions).

PHASE III: During this phase, the performance of the unit/system should be evaluated in a variety of field studies that will conclusively demonstrate that the unit/system meets the requirements of this topic. By the conclusion of Phase III, the selected contractor will have completed the development of the unit/system and will successfully

commercialized the product. The contractor should provide a report that summarizes the performance of the unit/system to the Armed Forces Pest Management Board (AFPMB) and will request a National Stock Number (NSN) be assigned. The contractor should coordinate in advance with the COR for any support required from the Walter Reed Army Institute of Research (WRAIR) or from the US Army Medical Research Institute of Infectious Diseases (USAMRIID).

Military Application: Once an NSN as been assigned to the unit/system the AFPMB will work with the appropriate organizations to have the unit/system incorporated into the appropriate "sets, kits, and outfits" that are used by deployed Preventive Medicine Units.

Commercial Applications: This unit/system will be made available for non-military purposes, such as for use by commercial pest controllers or non-governmental organizations (NGO's) in areas of the world where arthropod-borne diseases are an issue. We envision that the contractor that develops the unit/system will be able to market it to a variety of commercial, governmental, and non-governmental vector control organizations and testing facilities, and that this market will be adequate to sustain the continued production of the unit/system. By the end of Phase III, the selected contractor will be able to make this unit/system available to potential end-user customers throughout the world.

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KEYWORDS: arthropod-borne pathogen, arthropod, sample processing, disease risk assessment, vector surveillance

A12-116 TITLE: High Flow, Extended-Wear Respirators for Ambient Particulate Matter Protection

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop a rugged, novel particulate respirator or dust mask that is suitable for extended wear in military operational environments with high particulate matter levels during aerobic activity.

DESCRIPTION: Adverse health effects, including cardiovascular and pulmonary disease, are well-documented consequences of exposure to high levels of PM with aerodynamic diameter of less than 10 µm (PM10) and especially less than 2.5 µm (PM2.5). In many deployed environments, including regions of Southwest Asia (SWA), military personnel are continually exposed under normal conditions to levels of PM that exceed the military exposure guidelines (MEG) (1). These levels can be greatly exaggerated by anthropogenic activity or dust storms. There is a growing concern among pulmonologists—based primarily on anecdotal evidence—that exposures in SWA are leading to degraded respiratory function in a large number of service members (2). While operations in SWA have highlighted the risk, many military operations worldwide suffer the same burden. Unfortunately, current dust mask and respirator technologies are not suitable for extended wear during military operations (3,4), which require high levels of aerobic activity over sustained periods. The primary complaint which limits use of masks and respirators is discomfort caused by breathing resistance (5). Further, due to the extreme levels of PM in some

deployed settings, there is the recurring issue of clogging, which adds an additional logistics burden when masks need to be continually replaced. The objective of this project is to develop a rugged, novel particulate respirator or dust mask that is suitable for extended wear and significantly reduces the amount of dust respired in operational environments with high particulate matter levels, such as Southwest Asia. The ideal respirator shall allow high flow volumes with a minimal breathing resistance (sometimes called airflow resistance or pressure drop) and shall be suitable for wear during aerobic activity. It must also be resistant to clogging. Any technology capable of meeting the performance criteria will be considered. Priority shall be given to innovative or novel designs with minimal size and weight that are fully self-contained and have minimal to no power requirements.

PHASE I: Develop and demonstrate a filtration technology that significantly reduces PM10 and PM2.5 levels and is suitable for integration into a wearable device. The technology must be tested in a high PM environment (using polydispersed aerosol particles from 0.1-10 µm and concentrations of > 150 µg/m3 PM10 and > 40 µg/m3 PM2.5). Minimum operating characteristics for the Phase I demonstration include a low breathing resistance (< 5 mm of water inhale and < 3 mm of water exhale) at a moderate flow rate (85 L/min), a reduction of respirable particulate concentrations by greater than 90%, and a resistance to clogging for 12 hours (< 2x increase in breathing resistance in high PM environment challenge). The technical feasibility of improving the performance characteristics to levels indicated in Phase II should also be determined.

PHASE II: Develop and demonstrate a prototype particulate respirator or dust mask using the filtration technology develop in Phase I that meets or exceeds the following characteristics when tested in a high PM environment (using polydispersed aerosol particles from 0.1-10 µm and concentrations of > 150 µg/m3 PM10 and > 40 µg/m3 PM2.5) at a flow rate of 150 L/min:
1) Breathing resistance < 3 mm of water inhale and < 2 mm of water exhale
2) Respirable particle penetration of < 5 %
3) Resistance to clogging for 24 hours (< 2x increase in breathing resistance in high PM environment challenge)

Any reduction in exposure provided by a dust mask or respirator is dependent upon having a product that fits closely to the face and is correctly donned and worn. In order to address the need for proper fit, a fit assessment must demonstrate fit and the ability to easily don and doff the device. The fit characteristics of the device should be tested using a quantitative fit testing against a panel of human test subjects that adequately represent the intended users of the device. Examples of test panels include the Bivariate Panel, recently described by NIOSH's National Personal Protective Technology Laboratory (NPPTL), and the older Los Alamos National Laboratory Panel (6). The product should have a fit factor of at least 10 for 95% of the subjects.

To further accommodate the recurring daily use of the device, the prototype should be designed to ensure comfortable fitting with minimal facial abrasions due to extended wear under conditions with high levels of dirt, grit, or sand. The weight of the face mask should be less than 4 oz. The design must be user serviceable and any replaceable parts must be reusable for at least 30 days. In addition, a plan must be proposed on how to create a rugged design that is suitable for military operational use.

PHASE III: The overall goal of the project is to develop a NIOSH N95 compliant particulate respirator that has extreme performance characteristics for low breathing resistance and resistance to clogging. A ruggedized, military model suitable for field use has the potential to become standard issue to all troops deployed in dusty environments, including SWA. A commercial version will find a market across the hundreds of industries that require respirator use due to high dust levels (e.g. agriculture, construction, mining), but where compliance with use is limited due to poor performance characteristics.

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KEYWORDS: Respirator, particulate matter, pulmonary injury, dust mask, respiratory illness, high flow

A12-117 TITLE: Adapting SmartPhones for Ocular Diagnosis

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop a stereo-photo Smartphone ophthalmic slitlamp (system), with accessories and software applications for ocular diagnosis in remote or austere locations where ophthalmic or optometric support is unavailable, such as military forward operating bases, ships afloat, or disaster areas, or humanitarian missions.

DESCRIPTION: Ocular injuries currently account for approximately 13-22% of all combat casualties and up to 32% in disaster scenarios (1,2), while untold others experience other less devastating eye issues while deployed. Because the diagnosis and treatment of ocular trauma and disease are daunting to most non-ophthalmic providers, most opt to refer ocular patients to theater ophthalmologists or optometrists for evaluation of all but the most routine conditions; most often, however, those assets are very limited or non-existent in military operations so that transferring even relatively simple ocular conditions entails significant risk, or may not be possible at all (eg, ships afloat or humanitarian missions). In this regard, telediagnosis should offer both rapidity of evaluation and increased security; evacuation of the patient can then be more judiciously advised—or avoided—based on evaluation of the tele-information. Because Ophthalmology is so heavily reliant on visual information, high-quality photographic attachments are very helpful to the teleconsultants (3). Limitations to current photodocumentation are the 2-dimensional nature of standard photographs, the inability to selectively focus standard cameras on the microscopic structures of the ocular anatomy on which diagnoses can hinge, and overall resolution. Because of their size, weight, cost, fragility, and training requirements, conventional and portable slitlamps are not typically deployed in all forward clinical settings such as ships’ sick bays, Forward Operating Bases (FOBs), Battalion Aid Stations (BAS), disaster areas, or humanitarian missions, and when available are not equipped with photo capability (a technique that requires considerable skill in itself).

Smartphone technology has recently put high quality photography, advanced processing capability, and robust connectivity into the hands of technically untrained populations. Still photos or video can be captured and quickly edited for rapid dispatch via the internet in near real-time, or can be stored for later transmission. Continual advances in smartphone hardware have increased photographic resolution while decreasing the size of the cameras, and have even broached into 3-D applications.

Such handheld capability is of significant interest to military Ophthalmology. Inherent portability, connectivity, and affordability would allow use by minimally trained personnel and deployment to areas heretofore considered inaccessible or impractical. However, mere adaptation of existing smartphones may not answer all of the specialty’s needs. For example, a key aspect would be the capability to do high-resolution stereo photography of ocular structures that vary in scale from a few centimeters (external macro photography), to millimeters (microphotography of the surface of the eye), to sub-millimeter or microns (eg, internal structures such as the anterior chamber, lens and fundus). Additionally, selective illumination by slit beams of light cast at oblique angles allows greater precision in diagnosis unavailable in current smartphone technology.

Software applications should facilitate ophthalmic telediagnosis, to include collection of patient ocular exam data as well as enhanced photography/ videography and bundling for teleconsultation. Capacity should include both real-time and store-and-forward teleconsultation.

PHASE I: Develop an initial concept design, and create working models of key elements of a smartphone slitlamp or slitlamp system. Phase 1 deliverables should include: a highly specific design strategy that addresses and incorporates each of the listed minimum functional requirements, particularly with regard to ease of use, and modularity and adaptability for use in different configurations; proof of concept model(s) that addresses minimum functional requirements, particularly with regard to photographic and illumination requirements; and, initial examination, documentation, and teleconsultation software applications.

Minimum functional requirements include, but should not be limited to:
• ability to capture high quality 2-dimensional and stereo-photography (and/ or videography) of the eye(s) and adnexa;
• ability to transmit bundled examination data and photo information as near-real-time, or store-and-forward;
• ability to focus at different physical scales, from macro- (e.g., single eye or both; eyelids; adnexa; and gross ocular structures), to micro- (e.g., cornea, iris, lens, fundus etc) and sub-millimeter-scales, potentially including micron-scale (e.g., corneal epithelium , anterior chamber cells, etc);
• ability to focus principally on external and anterior internal ocular structures (i.e., lids, conjunctiva, sclera, cornea, etc) with flexibility to image deeper internal ocular structures (e.g., lens, fundus, optic nerve);
• ability to select lighting and illumination patterns from various direct or oblique angles, including, but not limited to, broad or diffuse beams, slit-beams, and pencil beams of light;
• ability to select from various illumination colors and wavelengths, such as (but not limited to) white, cobalt blue, red-free, and infrared lights;
• modular adaptability for use in a variety of platforms and configurations, such as freehand-operated, to stabilized-handheld (eg, a portable slit lamp platform), to table mounted (eg, a conventional slit lamp platform);
• adaptability to use in a variety of settings and environments, such as first-responder/ casualty-side in a field setting; bedside; or fixed facility/ clinic/ sick bay;
• adaptability to use in a variety of climatic conditions, such as extremes of heat and humidity, dust, rain, altitude, barometric pressure, etc;
• robust physical ruggedness to survive physical activities and abuses common to and expected of a combat, disaster, or otherwise austere environment;
• consideration of protection of camera lenses from scratching or other degradations that could adversely affect photo quality (especially at micro- and micron-scales);
• software applications to facilitate a detailed ocular examination (including pupil examination) by providers who are untrained or minimally trained in ocular diagnosis;
• overall ease of use by minimally trained personnel;
• appropriate instructional material and software.

Due to the time constraints regarding IRB and DoD second level review, no human or animal use studies should be proposed or executed during the six-month Phase I period.

PHASE II: Construct and demonstrate the operation of a prototype of the above integrated smartphone slitlamp system, to include both hardware and software components. Demonstrate the ability of the system to perform in a variety of situations and environments such as in the field, at the bedside, or in a more stable and fixed mode. Demonstrate easy use with acceptable results (photos and examinations) by minimally trained personnel. Demonstrate physical ruggedness.

PHASE III: The vision of this research is to create a novel ocular telediagnostic tool that can be used by minimally trained providers in remote, austere, or isolated environments such as military forward operating bases, ships afloat and away from port, or on humanitarian missions and in disaster zones where medical infrastructure and capability is reduced or nascent. Development of a smartphone-based ophthalmic slit lamp (or slitlamp system) would allow high-quality telemedicine consultations with ophthalmologists and optometrists, thereby potentially providing on-site diagnosis and treatment capability, and probably avoiding evacuation and minimizing security risks. The focus should be on technology transition or commercialization of this product. FDA approval (if needed) should be initiated or completed during this phase. Beyond military interest, commercial interest in this product could include disaster readiness organizations as well as humanitarian-relief organizations, and would not be limited to ocular diagnostics. Teleconsultation software applications could be attractive to other medical specialties. Advanced and stereophotographic capabilities could be attractive to the general public.

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KEYWORDS: Telemedicine, Ophthalmology, Slitlamp, Teleconsultation, Smartphone, Disaster medicine

A12-118 TITLE: SiC 600VDC Solid State Circuit Protection and Distribution

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design and demonstrate a Silicon Carbide (SiC) high voltage circuit protection to TRL 5 in TARDEC's Vehicle Electronics & Architecture (VEA) Research System Integration Lab (SIL) with future integration onto Joint Light Tactical Vehicle, Ground Combat Vehicle, and other future Army programs that will utilize a 600VDC architecture.

DESCRIPTION: In order to generate and distribute more electrical power on military ground vehicles, higher voltage architectures are necessary. Solid state 600VDC (+/- 300VDC) SiC circuit protection is a key piece of the architecture needing to be developed. Currently 600VDC SiC solid state circuit protection has not been demonstrated on military ground vehicles.

Requirements needed for high voltage circuit protection:
- Operate in -50C to 100C ambient environment (must use 105C coolant inlet if not air-cooled)
- Communicate using CAN J1939 for diagnostics, programming, on/off control
- Ground fault detection
- Arc Flash Protection
- Cable interlink protection
- Ability to "soft start" high voltage loads by limiting current inrush upon closing the circuit
- Circuits are default off when initially powered up
- Detect voltage and current on each output
- Detect temperature of internal electronics
- Meet MIL-STD Environmentals for Electro-Magnetic Interference
- Minimum Input is 200kW; Minimum Outputs are 37kW x3, 22kW, 18kW x3, 4kW x5
- Outputs can be ganged in any manner to achieve desired level of circuit protection

- Outputs can be programmed to trip below their max capability
- MIL-STD-1275D for control bias power
- Meet requriements in CHARACTERISTICS OF 600 VOLT DC ELECTRICAL SYSTEMS FOR MILITARY GROUND VEHICLES (available for public release).

The expectation is this will be a fully packaged, enclosed design.

PHASE I: Develop a proof of concept 600VDC SiC based power protection design that addresses the electrical protection features described above using SiC. A technically feasible solution must be analytically shown via modeling or objectively shown via real hardware in Phase I.

PHASE II: Build off phase I by completing electrical, thermal, mechanical, and functional aspects of the 600VDC SiC solid state protection power control solution for demonstration in the VEA Research SIL at TARDEC. Phase II will reach at least TRL 5 and commercial viability will be quantified

PHASE III: Final mechanical packaging (accounting for shock and vibration) and integration of the solution into a military ground vehicle utilizing a 600VDC architecture will occur.
Commercial Potential: provide commerical hybrid automotive systems with a reliable, high temperature, solid state ciruct protection to better protect and control the loads on their vehicles. Enable better designs for all electric vehicles.

REFERENCES:
1. CHARACTERISTICS OF 600 VOLT DC ELECTRICAL SYSTEMS FOR MILITARY GROUND VEHICLES

2. MIL-STD-1275D

KEYWORDS: Power Control Modules, Intelligent Power Distribution, Solid State Power Electronics, Silicon Carbide

A12-119 TITLE: Optical Communications for Control of Unmanned Ground Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop an optical communications system that is suitable for the teleoperation of unmanned ground vehicles (UGV).

DESCRIPTION: Radio frequency (RF) communications in the teleoperation of unmanned ground vehicles has always posed challenges due to interference and noise, potential for jamming, bandwidth, and latency. This topic seeks an alternative to RF communications by investigating recent progress in optical communications, which promises potentially higher bandwidth, less susceptibility to interference, jamming, and, perhaps, detection. Most existing land-based wireless optical communications systems are used for computer networks in areas where fiber optic implementation is difficult. Less work has been done in on-the-move optical communications, especially for ground vehicles. Typically, a teleoperation link is bi-directional with control information being sent to the unmanned system and requiring video and other vehicle data being sent back to the operator control unit (OCU).

The requirements for an optical communications system for UGV teleoperation are that the transceiver on the vehicle must be able to receive/transmit omnidirectionally, because the vehicle can be oriented in any direction relative to the OCU. The vehicle transceiver must be capable of operating with significant movement and vibration from the vehicle. The system must be eye-safe. The system should be applicable to teleoperation of vehicles as small as 20 Kg up to full-sized vehicles. The system should provide low latency, 50 ms or less. The system needs to provide sufficient bandwidth to allow full frame rate video suitable for teleoperating a vehicle in challenging environments. The system should operate in full daylight and at night. The system should allow for covert and/or secure communications. The system should have a range of two kilometers.

While most optical communications systems require line-of-sight, there is active research in non-line-of-sight (NLOS) optical communications. This topic is also soliciting for methods to achieve the stated requirements using NLOS technology and investigating the tradeoffs that may be required to achieve that capability.

PHASE I: The first phase consists of the initial system design, investigation of system components, and demonstration of feasibility. Documentation of the design, such as size, weight, and cost, trade-offs in the design space, and projected system performance, shall be required in the final report.

PHASE II: The second phase consists of a final design and full implementation of the system, including a camera for a robot, communications software and hardware, and a display system. At the end of the contract, successful operation of the prototype system controlling a robot shall be demonstrated in a realistic outdoor environment. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in the project and a user's guide and technical specifications for the prototype system.

PHASE III: Military applications include all those that entail wireless control of an unmanned system, especially those where RF communications can be problematic, such as bomb disposal and non line-of-sight operation. Civilian applications include law enforcement, and other users of unmanned systems.

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KEYWORDS: teleoperation, unmanned ground vehicle, optical communications, video