Small Business Technology Transfer (STTR)
Opportunity Announcement
HR001120S0019-18
Impact of Cockpit Electro-Magnetics on Aircrew Neurology (ICEMAN)

Which program will fund this topic?
STTR
What type of proposals will be accepted?
Phase I Only

Technology Area(s): Biomedical, Human Systems
DARPA Program: Air Combat Evolution (ACE)

I. INTRODUCTION

The Defense Advanced Research Projects Agency (DARPA) Small Business Programs Office (SBPO) is issuing an SBIR/STTR Opportunity (SBO) inviting submissions of innovative research concepts in the technical domain(s) of Biomedical, Human Systems. In particular, DARPA is interested in understanding the feasibility of Impact of Cockpit Electro-Magnetics on Aircrew Neurology (ICEMAN).

This SBO is issued under the Broad Agency Announcement (BAA) for SBIR/STTR, HR001120S0019. All proposals in response to the technical area(s) described herein will be submitted in accordance with the instructions provided under HR001120S0019, found here: https://beta.sam.gov/opp/b8abeb02f16a4450b2c2f859fc00c177/view.

a. Eligibility

The eligibility requirements for the SBIR/STTR programs are unique and do not correspond to those of other small business programs. Please refer to Section 3.1, Eligible Applicants, of HR001120S0019 for full eligibility requirements.

b. Anticipated Structure/Award Information

Please refer to Section 1, Funding Opportunity Description provided in HR001120S0019 for detailed information regarding SBIR/STTR phase structure and flexibility.

For this SBO, DARPA will accept Phase I proposals for cost of up to $225,000 for a 12-month period of performance.

Proposers should refer to Section 4, Application and Submission Information, of HR001120S0019 for detailed proposal preparation instructions. Proposals that do not comply with the requirements detailed in HR001120S0019 and the research objectives of this SBO are considered non-conforming and therefore are not evaluated nor considered for award.

Phase I proposals shall not exceed 20 pages. Phase I commercialization strategy shall not exceed 5 pages. This should be the last section of the Technical Volume and will not count against the 20-page limit. Please refer to Appendix A of HR001120S0019 for detailed instructions on Phase I proposal preparation.

Should DARPA have funding available and decide to proceed with a Phase II, proposers awarded a Phase I contract will be eligible to submit a proposal for Phase II and will be contacted by the DARPA Small Business Programs Office at the appropriate time during their Phase I period of performance. If selected, Phase II will have a Period of Performance of up to 24 months at $1M, with a 12-month option of $500,000.

c. Human Subjects Research (HSR)/Animal Use

Proposers that anticipate involving Human Subjects Research or Animal Use must comply with the approval procedures detailed at http://www.darpa.mil/work-with-us/additional-baa. For more information, refer to Section 4.7, Human Subjects/Research/Animal Use, of HR001120S0019.

Proposers are highly encouraged to clearly segregate research tasks from human and/or animal testing tasks to allow for partial funding while internal and DoD approvals are being obtained.

d. Evaluation of Proposals

Section 5, Evaluation of Proposals, in HR001120S0019 provides detailed information on proposal evaluation and the selection process for this SBO.

e. Due Date/Time

Full proposal packages (Proposal Cover Sheet, Technical Volume, and Price/Cost Volume inclusive of supporting documentation) must be submitted via the DoD SBIR/STTR Proposal Submission website per the instructions outlined in HR001120S0019 no later than **12:00 p.m. ET October 05, 2020.**

II. TOPIC OVERVIEW

a. Objective

Determine if the current air combat cockpit environment impacts cognitive performance and/or physiological sensor performance; quantify the effects; and demonstrate potential mitigation strategies.

b. Description

Current cockpits are flooded with radio frequency (RF) noise from on-board emissions, communication links, and navigation electronics, including strong electromagnetic (EM) fields from audio headsets and helmet tracking technologies. Pilots often report minor cognitive performance challenges during flight, and from 1993 to 2013, spatial disorientation in US Air Force pilots accounted for 72 Class A mishaps, 101 deaths, and 65 aircraft lost. It has been hypothesized that the cockpit RF and EM fields may influence cognitive performance including task saturation, misprioritization, complacency and Spatial Disorientation. However, EM fields and radio waves in cockpits are not currently monitored, little effort has been made to shield pilots from these fields, and the potential impacts of these fields on cognition have not been assessed.

Recent DARPA-funded research has demonstrated that human brains sense magnetic fields, like those used by animals for navigation, and that this process is "jammed" (i.e., disrupted) by radio waves (RF), impacting brainwaves and behavior. Furthermore, recent findings were the first to show that even weak RF fields and "earth strength" magnetic fields have measurable, reproducible effects on human brainwaves and unconscious behavior in a controlled environment. Current tactical audio headsets project magnetic fields up to 10 times earth strength, the effects of which can now be measured experimentally in a similar controlled environment. However, a need exists to assess these effects within a typical cockpit environment. Furthermore, as research efforts are increasingly seeking to assess aspects of human performance and cognitive state characteristics (e.g., cognitive workload, stress, and trust) within operational environments such as cockpits, a need exists to determine what effect, if any, the cockpit RF/EM environment may have on physiological sensor function and efficacy.

The DARPA Impact of Cockpit Electro-Magnetics on Aircrew Neurology (ICEMAN) STTR effort aims to 1) measure and manipulate the ambient EM field and RF noise in a typical cockpit, 2) measure potential effects of these electromagnetic stimuli on brain activity, physiology, and behavioral responses, and physiological sensing systems, and 3) demonstrate potential strategies to mitigate negative effects on aircrew neurology and sensor function.

c. Phase I

Demonstrate technical feasibility and proof of concept for measurement of EM fields and RF signals present in combat representative cockpits and empirical determination of potential impacts on aircrew neurology and physiological sensor performance. In Phase I, performers will be expected to investigate and provide a comprehensive summary of EM fields and RF signal equipment present in representative military cockpits, including Alternating Current (AC) and Direct Current (DC) EM fields from radar sources, active RF frequency bands, and signal intensity levels that are likely to exist in cockpit environments. If possible, performers are encouraged to collect initial representative measurements of fields and RF bands (i.e., 9 kHz - 1 GHz) for aircraft on the ground using existing and/or prototype sensing equipment (e.g., RF probes, spectral analyzers, search-coils, gauss meters). Due to the limited scope of Phase I no Government Furnished Equipment (GFE) will be provided but performers are encouraged to consider representative commercial aircraft (such as those with weather radars, typical avionics, and military-style helmets or headsets). The results of these measurements could be used to develop technical specifications for more sophisticated sensing equipment such as custom antenna systems to be developed in Phase II in support of more precise measurements. These measurements could also be used to develop a methodology for reproducing and modulating cockpit ambient EM/RF fields in a controlled laboratory setting such as an anechoic chamber. Finally, performers should develop a detailed methodology for how measurements will be conducted in Phase II, accounting for testing with and without human subjects, addressing considerations such as RF absorption by various tissues in the human body and brain.

At the end of Phase I, performers will need to demonstrate feasibility of conducting human subjects research (HSR) in both controlled laboratory settings and in real aircraft while controlling for confounding factors, particularly those present in live flight (e.g., gravitational loading, visual cues, geomagnetism, and stress). Detailed experimental design guidelines must be developed, and a draft Institutional Review Board (IRB) protocol should be outlined in the Phase I final report. A detailed protocol will be required as part of the Phase II proposal submission.

i. Schedule/Milestones/Deliverables

Phase I fixed payable milestones for this program should include:

- Month 1: Conduct kickoff meeting and finalize Phase I work plan based on PM feedback
- Month 6: Submit report summarizing in-situ measurements of magnetic and RF fields of representative aircraft or aircraft equipment (headsets, helments, avionics equipment, etc.)
- Month 12: Complete development of Phase II methodology and submit Phase I Final Report

Phase I deliverables: Reports summarizing 1) Magnetic and RF fields present in cockpits, 2) Phase I in situ cockpit EM/RF measurements if available, 3) Phase II sensor suite technical specifications, 4) Phase II experimentation plan, 5) Phase II draft IRB protocol.

d. Phase II

Develop next generation sensor suite capable of measuring the ambient EM/RF conditions in a military aircraft cockpit environment or a suitably similar analogue. This system must enable measurement of RF intensity vs frequency as well as RF absorption by various tissues in the human body and brain. These measurements will also be used to develop a methodology for reproducing and modulating cockpit ambient EM/RF fields in a controlled laboratory setting such as an anechoic chamber. Performers will validate these same EM/RF signals and magnetic field stimuli on human subjects in a controlled experimental setting and utilize physiological sensing and behavioral assays to quantify effects of signals on human magnetoreception, sensory perception, cognition, and behavior. Any effects of these fields on physiological sensors must also be assessed and characterized. Phase II will include human subjects research (HSR) in both controlled laboratory settings and in real aircraft while controlling for confounding factors, particularly those present in live flight (e.g., gravitational loading, visual cues, geomagnetism, and stress). Data collection should include testing in militarily relevant aircraft on the ground, in live flight, with and without radar, and during typical air combat flight maneuvers. Data collection should include and control for typical cockpit equipment such as radio headsets and electronics. Over the course of Phase II, performers will refine models, requirements, EM/RF measurement and generation prototypes, and experimental interventions.

The goal of Phase II experimentation will be to, not only identify any impacts of the cockpit EM/RF conditions that negatively impact pilot cognitive function or physiological sensor function, but also to develop and test various mitigation strategies to protect against these effects. Potential mitigation strategies could include methods for EM/RF shielding and attenuation. Prototype shielding systems will have to be tested in highly controlled settings as well as in live flight tests, accounting for potential confounding factors.

i. **Schedule/Milestones/Deliverables** Phase II fixed payable milestones for this program should include:
   - Month 1: Conduct kickoff meeting and finalize Phase I work plan based on PM feedback
   - Month 2: Finalize experimental design and submit IRB protocol
   - Month 6: Complete Phase II EM/RF sensor suite development and conduct EM/RF measurement data collection in representative aircraft on ground, in flight, and during flight maneuvers
   - Month 9: Complete Phase II EM/RF generation system development and begin lab-based testing
   - Month 12: Begin HSR experimentation in laboratory and ground-based cockpit settings
   - Month 18: Provide initial experimental findings and recommendations for potential mitigation strategies
   - Month 24: Provide demonstration and results of non-HSR mitigation strategy experimentation
   - Option Month 36: Provide demonstration and results of HSR mitigation strategy experimentation

Phase II deliverables: Reports summarizing 1) EM/RF sensing prototype technical specifications and functionality testing results, 2) cockpit EM/RF measurement experimentation, 3) EM/RF generation prototype technical specifications and functionality testing results, 4) HSR and non-HSR experimentation protocols and results.

e. Dual Use Applications (Phase III)

If this research and development effort reveals negative impacts of cockpit EM/RF environments on human cognitive function or physiological sensor performance, it is expected to generate interest from the commercial airline industry as well as other industries in which humans are exposed to similar EM/RF conditions. DoD/military applications include protection of performance optimization of aircrew, as well as other DoD personnel exposed to similar EM/RF conditions. Moreover, any successful mitigation strategies will be applicable and of interest to both commercial customers and DoD acquisition partners.

f. References

[1] Poisson, R.J. and M.E. Miller, Spatial disorientation mishap trends in the U.S. Air force 1993-2013. Aviat Space Environ Med, 2014. 85(9): p. 919-24

[2] Foxe, J.J. and A.C. Snyder, The role of alpha-band brain oscillations as a sensory suppression mechanism during selective attention. Frontiers in Psychology, 2011. 2

[3] Using reference models of the human head for RF measurements: Beard, B.B. and W. Kainz, Review and standardization of cell phone exposure calculations using the SAM phantom and anatomically correct head models. Biomedical Engineering Online, 2004. 3

g. Keywords

Psychology, Radiobiology, Anatomy and Physiology, Stress Physiology, Life Support Systems, Bioinstrumentation, Biological Instrumentation and Engineering

III. SUBMISSION OF QUESTIONS

DARPA intends to use electronic mail for all correspondence regarding this SBO. Questions related to the technical aspect of the research objectives and awards specifically related to this SBO should be emailed to HR001120S0019@darpa.mil. Please reference BAA HR001120S0019-18 in the subject line. All questions must be in English and must include the name, email address, and the telephone number of a point of contact.

DARPA will attempt to answer questions in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered. DARPA will post a consolidated Frequently Asked Questions (FAQ) document. To access the posting please visit: http://www.darpa.mil/work-with-us/opportunities. Under the HR001120S001918 summary, there will be a link to the FAQ. The FAQ will be updated on an ongoing basis until one week prior to the proposal due date.

In addition to the FAQ specific to this SBO, proposers should also review the SBIR/STTR General FAQ list at: http://www.darpa.mil/work-with-us/opportunities?tFilter=&oFilter=29934. Under the HR001120S0019 summary, there is a link to the general FAQ.

Technical support for the Defense SBIR/STTR Innovation Portal (DSIP) is available Monday through Friday, 9:00 a.m. – 5:00 p.m. ET. Requests for technical support must be emailed to DoDSBIRSupport@reisystems.com with a copy to HR001120S0019@darpa.mil.