VERSION 2

CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM
FY21.3 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

The approved FY21.3 topics included in the Chemical and Biological Defense (CBD) Small Business Innovation Research (SBIR) Program are listed below. Offerors responding to this Announcement must follow all general instructions provided in the Department of Defense (DoD) Program Announcement. Specific CBD SBIR requirements that add to or deviate from the DoD Program Announcement instructions are provided below.

Please read the entire DoD Announcement and these CBD SBIR instructions carefully prior to submitting your proposal. Also go to https://www.sbir.gov/about/about-sbir#sbir-policy-directive to read the SBIR/STTR Policy Directive issued by the U. S. Small Business Administration (SBA).

General Information

In response to Congressional interest in the readiness and effectiveness of U.S. Nuclear, Biological and Chemical (NBC) warfare defenses, Title XVII of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160) requires the Department of Defense (DoD) to consolidate management and oversight of the Chemical and Biological Defense (CBD) Program into a single office – Office of the Assistant Secretary of Defense for Nuclear, Chemical and Biological Defense Programs. The Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD), located at the Defense Threat Reduction Agency (DTRA), provides the management for the Science and Technology component of the Chemical and Biological Defense Program. Technologies developed under the Small Business Innovation Research (SBIR) Program have the potential to transition to the Joint Program Executive Office for Chemical Biological Radiological and Nuclear Defense (JPEO-CBRND) if the appropriate level of technology maturity is demonstrated. The JSTO-CBD Science & Technology programs and initiatives improve defensive capabilities against Chemical and Biological Weapons of Mass Destruction. The SBIR portion of the CBD Program is managed by the JSTO-CBD.

The mission of the Chemical and Biological Defense Program is to ensure that the U.S. Military has the capability to operate effectively and decisively in the face of chemical or biological warfare threats at home or abroad. Numerous factors continually influence the program and its technology development priorities. Improved defensive capabilities are essential in order to mitigate the overall impact of chemical and biological threats. The U.S. military requires the finest state-of-the-art equipment and instrumentation available to permit our warfighters to 'detect to warn' and avoid contamination, if possible – and to be able to sustain operations in a potentially contaminated environment. Further information is available at the Office of the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs homepage at https://www.acq.osd.mil/ncbdp/cbd/

The overall objective of the CBD SBIR Program is to improve the transition or transfer of innovative Chem-Bio technologies to the end user – the warfighter – in addition to commercializing technologies within the private sector for mutual benefit. The CBD SBIR Program targets those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection for both point and stand-off capabilities; individual and collective protection; hazard mitigation (decontamination); medical pre-treatments (e.g., vaccine development and delivery); medical therapeutics (chemical countermeasures and biological countermeasures); medical diagnostics; Digital Battlespace Management (aka information systems technology) to include but not limited to modeling and simulation (e.g., meteorological dispersion), disease surveillance, data fusion, and health & human effects to include wearable technologies.

VERSION 2

Proposals not conforming to the terms of this Announcement will not be considered. CBD SBIR reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by CBD SBIR will be funded. CBD SBIR reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, or other related issues).

Use of Foreign Nationals (also known as Foreign Persons), Green Card Holders, and Dual Citizens

See the "Foreign Nationals" section of the DoD SBIR Program Announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals, green-card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on the project. You may be asked to provide additional information during contract negotiations in order to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Submitting Your Phase I CBD SBIR Proposal

Your entire proposal submission must be submitted electronically through the Defense SBIR/STTR Innovation Portal (DSIP) located at: https://www.dodsbirsttr.mil

A hardcopy is NOT required and will not be accepted by the Chemical and Biological Defense SBIR Program. Hand or electronic signature on the proposal is NOT required.

Any questions pertaining to the DoD SBIR/STTR submission system should be directed to the DoD SBIR/STTR Help Desk: DoDSBIRSupport@reisystems.com

The Proposal Technical Volume must be 20 pages or less in length. No other information included in the other proposal volumes counts against the 20-page Proposal Technical Volume page limit. Pages provided in excess of this length will not be evaluated or considered for review. The proposal must not contain any type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

The Company Commercialization Report (CCR) must be uploaded as Volume 4, in accordance with the instructions provided in the DoD Program BAA. Information contained in the CCR will not be considered during proposal evaluations.

The maximum dollar amount for a Phase I proof-of-concept/feasibility study is $167,500 for a period of performance of up to six (6) months. **The CBD SBIR Program will not accept Phase I proposals which exceed $167,500 for the Phase I effort**. The total SBIR funding amount available for Phase II activities from a resulting Phase II contract is not to exceed $1,100,000.

Selection of Phase I proposals will be based upon the three evaluation criteria discussed in this Program Announcement. The CBD SBIR Program reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality in the judgment of the technical evaluation

team will be funded. All SBIR contract awards, both Phase I and Phase II, are subject to availability of funding.

Companies should plan carefully for any research involving animal or human subjects, chemical agents, biological agents, etc. The brief Period of Performance available for a Phase I project precludes plans that include these elements, as all DoD requirements and necessary approvals associated with animal and/or human use must be strictly adhered to, and require considerable coordination and significant time for final protocol approvals. See Section below for further information regarding all research that will include animal and/or human subjects.

Proposals not conforming to the terms of this Announcement, and any unsolicited proposals, will not be considered. All awards are subject to the availability of funding and successful completion of contract negotiations. The Chemical and Biological Defense Program is not responsible for any funds expended by the proposer prior to contract award.

CBD Program Phase II Proposal Guidelines

Phase II is the demonstration of the technology that was found feasible in Phase I. Phase I awardees may submit a Phase II proposal without invitation; however, it is strongly encouraged that a Phase II proposal not be submitted until sufficient Phase I progress can be evaluated and assessed based on results of the Phase I proof-of-concept/feasibility study. Therefore, it is suggested that a Phase II proposal be submitted no sooner than five months from date of Phase I contract award. **All Phase II proposal submissions must be submitted electronically through the Defense SBIR/STTR Innovation Portal system at: https://www.dodsbirsttr.mil**

At the proposal submission website, Phase II proposals MUST be submitted to '**CBD** SBIR' regardless of which DoD contracting office negotiated and awarded the Phase I contract. Additional instructions regarding the Phase II proposal submission process including submission key dates will be provided to Phase I awardees after the Phase I contract is awarded; additional information may also be found at http://www.cbdsbir.net.

The Phase II proposal must include a concise summary of the Phase I project including the specific technical problem or opportunity addressed and its importance, the objective of the Phase I project, the type of research conducted, findings or results of this research, and technical feasibility of the proposed technology. Due to limited funding, the CBD SBIR program reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

All proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing and manufacturing the developed technology. Proposers are required to submit a budget for the entire 24-month Phase II Period of Performance. During contract negotiation, the Contracting Officer may require a Cost Volume for a base year and an option year; thus, proposers are advised to be aware of this possibility. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD SBIR/STTR submission site). The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. At the Contracting Officer's discretion, Phase II projects may be evaluated for technical progress prior to the end of the base year, prior to extending funding for the option (second) year.

The CBD SBIR Program is committed to minimizing the funding gap between Phase I and Phase II activities. The CBD SBIR Program typically funds a cost plus fixed fee Phase II award, but may award a firm fixed price contract at the discretion of the Contracting Officer.

VERSION 2

It is recommended that Phase II awardees have a Defense Contract Audit Agency (DCAA) approved accounting system. If you do not have a DCAA approved accounting system, this could delay/prevent a Phase II contract award. Visit https://www.dcaa.mil/Customers/Small-Business for more information on DCAA approved accounting systems.

Technical Assistance

At this time, the CBD SBIR Program is not participating in the Technical and Business Assistance (TABA) Program.

Fraud, Waste and Abuse

All offerors must complete the fraud, waste, and abuse training (Volume 6) that is located on the Defense SBIR/STTR Innovation Portal (DSIP) (https://www.dodsbirsttr.mil). Please follow guidance provided on DSIP to complete the required training prior to submitting proposals.

To Report Fraud, Waste, or Abuse, Please Contact:
DoD Inspector General (IG) Fraud, Waste & Abuse
Hotline: (800) 424-9098
hotline@dodig.mil

Additional information on Fraud, Waste and Abuse may be found in the DoD Instructions of this Announcement.

Protest Procedures

Refer to the DoD SBIR Program Announcement for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Mr. Larry Pollack, Chemical and Biological Defense (CBD) SBIR Program Manager, Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD), lawrence.p.pollack2.civ@mail.mil

CBD SBIR Projects Requiring Animal and Human Subjects

Companies should plan carefully for any research involving animal and/or human subjects in addition to the use of any chemical or biological warfare agents, and use of any agents associated with "Dual Use Research of Concern (DURC)". The brief Phase I Period of Performance precludes plans requiring the use of many of these materials as well as animal and/or human subjects prior to obtaining all necessary DoD approvals.

The offeror is expressly forbidden to use or subcontract for the use of laboratory animals in any manner without the express written approval of the U.S. Army Medical Research and Development Command's (USAMRDC), Animal Care and Use Review Office (ACURO). Written authorization to begin research under the applicable protocol(s) proposed as part of the CBD SBIR program will be issued after contract award in the form of an approval letter from the USAMRDC ACURO to the recipient. Furthermore, modifications to already approved protocols require approval by ACURO prior to implementation.

Research under CBD SBIR awards involving the use of human subjects, to include the use of human anatomical substances or human data, shall not be proposed for any Phase I Period of Performance. If Human Subjects research is proposed during the Phase II Period of Performance, the studies may not begin until the DTRA Research Oversight Board (ROB) provides authorization that the research protocol

may proceed. Written approval to begin research protocol will be issued from the ROB, under separate notification to the recipient. Written approval from the ROB is also required for any sub-recipient that will use funds obtained from any CBD SBIR awards to conduct research involving human subjects.

Changes in research involving human subjects shall be conducted in accordance with the protocol submitted to and approved by the ROB. Non-compliance with any provision may result in withholding of funds and or termination of the award.

Notification of Selection or Non-selection

Proposing firms will be notified of Selection or Non-selection status for a Phase I award within 90 days of the closing date of the BAA. The individual named as the Corporate Official in addition to the Principal Investigator will be notified using the email addresses provided on the Proposal Cover Sheet. These individuals will receive an email for each proposal submitted with official notification of proposal Selection or Non-selection. The email will originate from: notification@dtrasubmission.net and will be provided by the CBD SBIR Program Manager.

VERSION 2

CBD SBIR 21.3 Phase I Topic Index

VERSION 2

TOPIC: CBD213-001

TITLE: Surface-Enhanced Raman Scattering Substrate Development

KEY TECHNOLOGY AREA(S): Chemical/Biological Defense; Materials/Processes

OBJECTIVE: To develop a metallic surface-enhanced Raman scattering (SERS) substrate to be utilized for augmentation of current/future Raman spectroscopic portable instrumentation for the detection of trace and residual chemical materials. The substrates should consist of nanostructured metals, preferably gold or silver, on a porous or non-porous material backing (such as filter paper, silicon, gallium nitride, etc.), with no less than 3 mm x 3 mm and no larger than 4 x 4 mm active SERS area providing the SERS enhancement, and be useable with minimally 633 nanometer (nm) or 785 nm excitation.

DESCRIPTION: Raman spectroscopy has proven to be a reliable field deployable detection technique for assessing chemical threats, including chemical warfare agents, energetic materials, and illicit narcotics. Military and Homeland Security agencies commonly utilize various portable Raman systems in sensitive site exploitation, checkpoint scenarios, and to determine hazardous content on surfaces or containers. Enhanced Raman techniques, such as surface-enhanced Raman scattering (SERS) have been demonstrated to be a vibrant field of research that is growing significantly in scope and applicability while pushing at the ultimate limits of sensitivity. SERS occurs when nanometallic substrates locally amplify electromagnetic fields at or near particle surfaces providing enhancements over 'normal' Raman spectroscopy, typically over a million-fold. Along with other advantages such as reduction of interfering fluorescence, decreased detection times, and reduction of laser power required for analysis, SERS has been positioned to be an ideal technique for low-level, low-consumable detection schemes, while aiming towards miniaturization of instrumentation.

The problem to date, however, is the lack of commercially available robust SERS active substrates that have an inherent low background signature which ultimately interferes with obtaining clean SERS spectra from low-level concentrations of threat analytes, while still having at least 10^4 SERS enhancement. The goal of this topic and the resulting research is to develop miniature metal-based surface-enhanced Raman spectroscopy substrates which could be manufactured at a large scale, while retaining both low-level baseline signatures (native background peaks are minimal) and low contaminant levels, to be utilized in various chemical and biological detection scenarios for augmentation of portable Raman technologies.

PHASE I: Develop a conceptual design for the surface-enhanced Raman substrate detailing the technical feasibility of the proposed design and production of the substrate. Technical feasibility shall be demonstrated through modelling, production capability infrastructure, proposed optimal (633 nm or 785 nm) and non-optimal wavelength (< 400 nm or >800 nm) use, and theoretical shelf-life. This demonstration will elucidate the minimal SERS background spectral features when exposed to clean de-ionized water for a minimum of 10 minutes. The demonstration will also provide an estimated SERS enhancement value to be equal to or greater than 10^4. Use of 1,2-bis(4-pyridyl)-ethylene to determine the SERS enhancement value is encouraged. Of importance is a clean substrate with minimal production/manufacturing contamination present, so that the maximum potential exists for the binding of typically weakly bound analytes.

VERSION 2

Demonstration of technical feasibility in Phase I is required for consideration of a Phase II project award.

PHASE II: Following technical feasibility demonstration of the Phase I requirements, the small business shall develop manufacturing protocols for the design and delivery of 500 substrates after 10 months, and 1000 SERS substrates after 24 months, meeting the goals of a 10^4 or better enhancement with native surface background Raman features (with no analyte present) not exceeding 3 times the background noise level with the same laser power and integration time with which a SERS Raman spectrum is obtained. The purposes of a low native surface background are both to reduce spectral interference and to maintain the maximum number of possible available binding sites for user introduced analytes. Also, spectral reproducibility characteristics of the substrates need to be within 30% for a measured analyte over 50 individual substrate measurements (analyte to be determined) obtained by comparison of peak areas across the measurements. The substrates will be tested by U.S. Army DEVCOM-CBC for requirement compliance.

PHASE III: Following successful delivery of 1000 SERS substrates meeting the performance characteristics in Phase II, protocols for scale-up manufacturing will be developed in order to deliver thousands of substrates which can be utilized in various chemical and biological detection applications for the augmentation of field portable Raman spectroscopy systems. Methods for QA/QC will be developed to ensure standardization during mass production. In addition, packaging for shipment will be developed with the goal of protecting the substrates and minimizing additional contamination.

PHASE III DUAL USE APPLICATIONS: In addition to use for the Department of Defense (DoD) low-level chemical detection scenarios, the designed SERS surfaces have commercialization activity for low-level explosive detection and biological detection for civilian uses by first responders and law enforcement personnel. DoD uses could include sensitive site exploitation, explosives detection, post decontamination survey and verification, and may serve as a technology upgrade for current and future portable Raman spectroscopic technologies. Civilian uses could include identification of illicit drugs and inspection of food products and/or hazardous waste containers.

REFERENCES:

1. Emmons, E. D., Guicheteau, J. A., Fountain III, A. W., Tripathi, A. “Effect of Substituents on Surface Equilibria of Thiophenols and Isoquinolines on Gold Substrates Studied Using Surface-Enhanced Raman Spectroscopy”. Phys. Chem. Chem. Phys. 2020, 22, 15953-15965.

2. Tripathi, A., Emmons, E. D., Kline, N. D., Christesen, S. D., Fountain III, A. W., and Guicheteau, J. “Molecular Structure and Solvent Factors Influencing SERS on Planar Gold Substrates”, J. Phys. Chem. C. 2018, 122 (18), 10205–1021.

3. Guicheteau, J. A., Tripathi, A., Emmons, E. D., Christesen, S. D., Fountain III, A. W. “Reassessing SERS enhancement factors: using thermodynamics to drive substrate design”. Faraday Discuss. 2017, 205, 547-560.

4. Guicheteau, J. A, Farell, M. E., Christesen, S. D., Fountain III, A. W., Pelligrino, P. M., Emmons, E. D., Tripathi, A., Wilcox, P., Emge, D. “Surface-enhanced Raman Scattering (SERS) Evaluation Protocol for Nanometallic Surfaces”. Appl. Spec. 2013, 67, 4, 396-403.

KEYWORDS: Surface-enhanced Raman Spectroscopy; SERS; Metallic Nanostructures; Chemical Detection

VERSION 2

TOPIC: CBD213-002

TITLE: Millimeter Wave Imaging with Metamaterials

KEY TECHNOLOGY AREA(S): Chemical/Biological Defense; Materials/Processes

OBJECTIVE: To develop a low-cost millimeter wave imager based on pyroelectric metamaterial absorbers. The goal is to develop an advanced composite detector fashioned from metamaterials that can be assembled into compact arrays for low cost hyperspectral and high sensitivity W-band imaging applications.

DESCRIPTION: Millimeter wave imaging has been shown to be a useful tool in the detection of potential threats to military personnel. Examples include the use of millimeter wave imaging for chemical/biological detection, person-borne improvised explosive device detection, land-mine detection, and unmanned aerial system (UAS) detection. W-band (75 to 110 GHz) imagers have proven to be particularly useful to the military for the detection of threats. A low-cost solution to imaging in the millimeter wave region has the potential to provide significant benefits to numerous applications within the Department of Defense (DoD) Science & Technology programs.

Electromagnetic metamaterials have demonstrated the ability to provide frequency dependent high absorptivity at millimeter wavelengths, and a W-band detector with optical read-out has been demonstrated. A common metamaterial absorber design uses a metal ground plane, dielectric layer, and a top layer of patterned metal. The metamaterial detectors use thin film pyroelectric materials as the dielectric spacer, thus enabling high absorptivity, and direct read-out of the detected signal. Metamaterial enhanced bimaterial cantilever pixels have been demonstrated for far-infrared detection.

At least two types of metamaterial detector structures may be considered for millimeter wave imaging applications: (1) symmetric metamaterial absorbers (SMA) for coherent amplitude and phase detection, and (2) asymmetric or ground plane metamaterial absorbers (GPA), for intensity-only detection. While both SMA and GPA structures can be used for hyperspectral sensing, the coherent SMA structure provides phase sensitive, vector mode, sensing capabilities that are especially important in millimeter wave imaging applications.

A W-Band imager should be able to detect objects at a distance of at least 10 meters and possess a noise equivalent temperature difference (NETD) of 5 degrees Kelvin (K) or less. The imager should be able to detect targets with a resolution of 10 cm or better at a distance of 10 meters.

PHASE I: Develop and test a single pixel detector operating at 95 GHz. Demonstrate that the system can detect a NEDT of 5 degrees or less. Explore the use of a coherent structure that provides phase sensitive, vector mode, sensing capabilities. Develop a design of an imager operating in the W-Band that can detect objects to at least a distance of 10 meters with a resolution of 10 cm or better with a NEDT of 5 degrees K or less.

PHASE II: Construct and demonstrate a working prototype W-Band imaging system using the design developed in Phase I. Demonstrate the imager using targets and black bodies at a distance of 10 meters or more. Demonstrate that the system can detect objects to at least a distance of 10

meters with a resolution of 10 cm or better with a NETD of 5 degrees K or less. Deliver the working prototype to the Government for further testing.

PHASE III: Further research and development during Phase III efforts will be directed toward refining the final deployable equipment and procedures. Design modifications based on results from tests conducted using the Phase II deliverable will be incorporated into the system. Manufacturability specific to U.S. Army Concepts of Operation (CONOPS) and Chemical and Biological Defense Program end-user requirements will be examined.

PHASE III DUAL USE APPLICATIONS: The development of a low-cost solution to imaging in the millimeter wave region has the potential to provide significant benefits to numerous programs within the DoD as well as other Government Agencies.

REFERENCES:

1. P.K. Singh, K.A. Korolev, M.N. Afsar, S. Sonkusale, "Single and dual band 77/95/110 GHz metamaterial absorbers on flexible polyimide substrate," Appl. Phys. Lett. 99, 264101 (2011).

2. H. Tao, E.A. Kadlec, A.C. Strikwerda, K. Fan, W.J. Padilla, R.D. Averitt, E.A. Shaner, X. Zhang, "Microwave and Terahertz wave sensing with metamaterials," Opt. Exp. 19, 21620 (2011).

3. J.Y. Suen, K. Fan, J. Montoya, C. Bingham, V. Stenger, S. Sriram, W.J. Padilla, "Multifunctional metamaterial pyroelectric infrared detectors," Optica 4, 276-279 (2017).

4. M.R. Webb, "A millimeterwave pyroelectric detector," International Journal of Infrared and Millimeter Waves 12, 1225–1231 (1991).

5. T.W. Du Bosq, J.M. Lopez-Alonso, G.D. Boreman, D. Muh, J. Grantham, D. Dillery, "Millimeter wave imaging system for the detection of non-metallic objects," Proc. of SPIE Vol. 6217 621723-10 (2006).

6. T.W. Du Bosq, J.M. Lopez-Alonso, G.D. Boreman, "Millimeter wave imaging system for land mine detection," Applied Optics 45, 5686-5692 (2006).

7. J.P. Samluk, C.A. Schuetz, R.D. Martin; E.L. Stein Jr., D.G. Mackrides, C. Chen, P. Yao, R. Shireen, J. Macario, D.W. Prather, "94 GHz millimetre-wave imaging system implementing optical upconversion,", Proc. SPIE 7117, Millimetre Wave and Terahertz Sensors and Technology, 71170T (2 October 2008).

8. J.P Samluk, D.W. Prather, et al., "Demonstration of Passive W-Band Millimeter Wave Imaging Using Optical Upconversion Detection Methodology with Applications," J. of Infrared, Millimeter, and Terahertz Waves, vol. 33, no. 11, pp.1076-1084, (2012).

9. S.A. Mousavi, E. Plum, J. Shi, N.I. Zheludev, "Coherent control of optical polarization effects in metamaterials," Scientific Reports, Mar 10, 2015.

10. J. Chen, H. Zhao, L. Yan, Y. Dai, “A new type of coherent electromagnetic radiation source based on interference effect between forward and backward waves in an active metamaterial slab,” Applied Physics A, (2019) 125:255.

11. Q. Yang, B. Li, Z. Lan, Y. Li, Z. Zhu, J. Shi, “Coherent absorption in optical metamaterials,” SPIE Proceedings, vol. 10824, Plasmonics III; 1082408 (2018).

12. H. Tao, W. J. Padilla, X. Zhang, and R. D. Averitt, “Recent progress in electromagnetic metamaterial devices for terahertz applications,” IEEE J. Sel. Top. Quantum Electron. 17(1), 92–101 (2011).

KEY WORDS: millimeter wave imaging; metamaterials; hyperspectral; W-Band