CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM
SBIR 12.2 Proposal Submission

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) required 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 Deputy Assistant to the Secretary of Defense for Chemical and Biological Defense Programs. The Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD), 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 SBIR program have the potential to transition to the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) if the appropriate level of technology maturity has been demonstrated. The JSTO-CBD Science & Technology programs and initiatives are improving defensive capabilities against Chemical and Biological Weapons of Mass Destruction. The Small Business Innovation Research (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. Numerously factors continually influence the program and its technology development priorities, including planning for warfighting support to asymmetrical threats, the evolving geopolitical environment, development of new threat materials, the threat of global proliferation of chemical and biological weapons, and available DoD resources. Improved defensive capabilities are essential in order to minimize the impact of such weapons. The U.S. military requires the finest state-of-the-art equipment and instrumentation available that permits our warfighters to detect to warn and avoid contamination, if possible -- and to be able to sustain operations in a potentially contaminated environment through protection and decontamination. Further information regarding the DoD Joint Chemical and Biological Defense program is available at the DoD Counterproliferation and Chemical Biological Defense homepage at http://www.acq.osd.mil/cp

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); information systems technology to include but not limited to modeling and simulation and operational effects & mitigation; medical pre-treatments (e.g., vaccine development and delivery); medical diagnostics & disease surveillance; and medical therapeutics (chemical countermeasures and biological countermeasures).

Submitting Your Phase I CBD SBIR Proposal

Your entire proposal (consisting of Proposal Cover Sheets, the full Technical Proposal, Cost Proposal, and Company Commercialization Report) must be submitted electronically through the DoD SBIR/STTR Proposal Submission system located at www.dodsbir.net/submission. A hardcopy is NOT required for CBD. Hand or electronic signature on the proposal is also NOT required.

The Proposal Cover Sheets and technical proposal is 25 pages or less in length. The Cost Proposal and Company Commercialization Report do not count against the 25 page limit. Pages in excess of this length will not be considered for review or award. The proposal must not contain any type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

You must prepare a Company Commercialization Report through the Submission site and it will be included with your electronic submission; however, it does not count against the proposal page limit. Update your commercialization information if you have not done so in the past year. Please note that improper handling of the Commercialization Report may result in the proposal being substantially delayed and that information provided may have a direct impact on the review of the proposal. Refer to section 3.5d at the program solicitation for detailed instructions on the Company Commercialization Report.

Be reminded that section 3.5.a of this solicitation states: "If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet; therefore, do not include proprietary or classified information in these sections". Note also that the DoD web site contains timely information on firm, award, and abstract data for all DoD SBIR Phase I and II awards archived for several years. This information can be viewed on the DoD SBIR/STTR website at http://www.acq.osd.mil/osbp/sbir/index.shtml.

The CBD SBIR Program uses a Phase I Option to enhance the Phase I to Phase II transition process; the Phase I option may be exercised to fund interim Phase II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I feasibility study is $100,000. The Phase I Option, which **must** be proposed as part of the Phase I proposal, covers activities over a period of up to three months and at a cost not to exceed $50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities, which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The CBD SBIR program will not accept Phase I proposals which exceed $100,000 for the Phase I effort and $50,000 for the Phase I Option effort**. Only those Phase I efforts selected for Phase II awards through the CBD SBIR Program's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of $1,150,000, the total funding amount available for Phase II activities from a resulting Phase II contract will be $1,000,000.

Companies submitting a Phase I proposal under this Solicitation must complete the Cost Proposal using the on-line form within a total cost of $100,000 over a period of up to 6 months (plus up to $50,000 for the Phase I Option over a period of up to three (3) months). Phase I and Phase I Option costs must be shown separately.

Selection of Phase I proposals will be based upon the evaluation procedures and criteria discussed in section 4.2. 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.

Proposals not conforming to the terms of this solicitation, and unsolicited proposals, will not be considered. Awards are subject to the availability of funding and successful completion of contract negotiations.

CBD Program Phase II Proposal Guidelines

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which achieved success in Phase I, as determined by the project technical

monitor measuring the results achieved against the criteria contained in section 4.3, will be invited to submit a Phase II proposal. During or at the end of the Phase I effort, awardees will be invited to submit proposals for consideration of a Phase II award based on the results of the Phase I effort. The invitation will be issued in writing by the organization responsible for awarding the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Proposers are required to submit a budget for the entire 24 month Phase II period. During contract negotiation, the contracting officer may require a cost proposal 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 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. At the Contracting Officer's discretion, Phase II projects may be evaluated after the base year prior to extending funding for the option year.

The CBD SBIR Program is committed to minimizing the funding gap between Phase I and Phase II activities. All CBD SBIR Phase II proposals will receive expedited reviews and be eligible for interim funding (refer above for information regarding the Phase I Option). Accordingly, all Phase II proposals will be evaluated within a single multi-tiered evaluation process and schedule. Phase II proposals will typically be invited for submission within 5 months from the scheduled DoD Phase I award date (the scheduled DoD award date for Phase I, subject to the Congressional Budget process, is 4 months from close of the DoD Solicitation). The CBD 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.

Key Dates

12.2 Solicitation Pre-Release	24 April 2012 – 23 May 2012
12.2 Solicitation Open/Close	24 May 2012 – 27 June 2012
Phase I Evaluations	June - August 2012
Phase I Selections	September 2012
Phase I Awards	November 2012*
Phase II Invitations	April 2013
Phase II Proposals Due	May 2013

*Subject to the Congressional Budget process.

CBD SBIR PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets the CBD SBIR requirements. **Failure to meet these requirements will result in your proposal not being evaluated or considered for award**.

_____ 1. The Proposal Cover Sheets along with the Technical Proposal, Cost Proposal and Company Commercialization Report were submitted via the Internet using the DoD's SBIR/STTR Proposal Submission website at http://www.dodsbir.net/submission.

_____ 2. The proposal cost adheres to the CBD Program criteria specified.

_____ 3. The proposal is limited to only **ONE** solicitation topic. All required documentation within the proposal references the same topic number.

_____ 4. The Project Abstract and other content provided on the Proposal Cover Sheet contains no proprietary or classified information and is limited to the space provided.

_____ 5. The Technical Content of the proposal, including the Option (if applicable), includes the items identified in Section 3.4 of the solicitation.

_____ 6. The Proposal Cover Sheets and technical proposal is 25 pages or less in length. The Cost Proposal and Company Commercialization Report do not count against the 25 page limit. Pages in excess of this length will not be considered for review or award.

_____ 7. The Company Commercialization Report is submitted online in accordance with Section 3.5.d. This report is required even if the company has not received any SBIR funding

_____ 8. The proposal must not contain any type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

CBD SBIR 12.2 Topic Index

CBD SBIR 12.2 Topic Descriptions

CBD12-101 TITLE: Formulation Development to Enhance Bioavailability and Pharmacokinetic Profile of Protein-based Drugs

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Develop novel methods to improve bioavailability and pharmacokinetic profile of protein-based drugs.

DESCRIPTION: Protein-based drugs are becoming an increasingly important class of drugs. A great deal of effort is being made to improve their efficacy by improving their bioavailability and increasing their stability within the circulatory system. For example, Human-derived Butyrylcholinesterase (hBuChE) remains to be an effective treatment for pre- and post- exposure to nerve agents. Human BuChE is produced from outdated human plasma and requires large quantities for production. Estimates made in 2008, indicate that the existing capabilities to process blood to be used for bioscavenger production could only make 100,000 doses of bioscavenger per year, far below the estimates needed for protecting the entire military and civilian population. Since the source is limited, it necessitates the need to find an alternate, more reliable source of hBuChE. To date, much of the research has focused on recombinant expression systems. Human BuChE has been successfully made from transgenic goats, transgenic plants, and cultured mammalian cells. Unfortunately several challenges have been identified using these alternate systems. These challenges include:

1.) Reduced bioavailability in the blood

2.) Short half life in the blood stream

There are several methods that can be employed to increase the half life of proteins, including pegylation, sialylation etc. It is thought that sialic acids on hBuChE may be responsible for its half-life in the blood stream.

To resolve the challenges, formulation development should focus on the following:

1.) Delivering a protein either intramuscularly or subcutaneously and have it be rapidly (within minutes) bioavailable in the blood.

2.) Delivering a protein intramuscularly or subcutaneously that will be enzymatically active and have an extended circulatory presence (multiple days) without inducing an immune response or causing any pathology.

3.) Store an enzyme for long periods of time on the shelf without loss of activity, in a format that is either ready for injection or can rapidly be made ready for injection.

The current goal for a maximum dose of a bioscavenger is 1 mg/kg (or roughly 80 mg/adult person), with proteins that are soluble in the 2-20 mg/ml range. It is possible that a dry or semi-solublized formulation could be injected. The key parameter is getting active enzyme into the blood.

Development of a technique(s) to improve the bioavailability and stability in the circulatory system of a bioscavenger like BuChE could be applied to any protein-based drug that could be used in Chemical and Biological Defense treatments.

PHASE I: Initially, develop a formulation(s) that will improve the bioavailability (within minutes of administration) and pharmacokinetic profile of a protein-based drug, selected by the proposer. The product formulation should extend its shelf life and be readily amenable for intramuscular or subcutaneous injection. Demonstration of the formulation should be evaluated for 2 different proteins in vitro to show that there is no loss of protein activity due to the protein modifications or formulation.

PHASE II: Evaluate the pharmacokinetic profile of the formulated protein in plasma in an appropriate animal model to demonstrate that the formulation is superior to existing methodology with regards to protein half-life (greater than 2-fold increase) compared to native protein. In addition, perform toxicologogical and immunological studies in an appropriate animal model to demonstrate that the formulations and modification to the protein does not induce toxicity or an undesired immune response. Demonstration should be conducted on 2 proteins selected by the proposer.

PHASE III: Conduct further characterization of the formulated proteins. The proposer should also begin developing a pilot-scale manufacturing process of the formulated protein(s) internally or with a collaborator. An appropriate transition or collaborative partner(s) who will implement this technology in their cGMP manufacturing of protein-based drugs to support the warfighter mission or commercial interests should be identified.

REFERENCES:
1. Ross et al. (2008) Medical Aspects of Chemical Warfare, (Lenhart editor) Chapter 7, Office of the Surgeon General.

2. Huang et al. (2007) Proceedings of the National Academy Sciences USA 104: 13603-13608.

3. Geyer et al. (2010 Plant Biotechnology Journal 8: 873-886.

4. Geyer et al. (2010) Proceedings of the National Academy Sciences USA 107: 20251-20256.

5. Duysen et al. (2002) Journal of Pharmacology and Experimental Therapeutics 302: 751-758.

6. Kronman et al. (2000) Journal of Biological Chemistry 275: 29488-29502.

KEYWORDS: bioscavenger, chemical, biodefense, enzymes, medical countermeasures, butyrylcholinesterase

CBD12-102 TITLE: Advanced Purification Technology for the Manufacture of Vaccines, Biologic Drugs, and Enzymes

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Develop novel, non-synthetic-resin-based protein purification technologies that enables the low-cost production of kilogram quantities of proteins for chemical and biological defense applications.

DESCRIPTION: Recent investments by the DoD have been made in areas to increase the agility of the government to respond to a future pandemic or chemical/biological threat in development of appropriate countermeasures. This includes novel manufacturing platforms that can rapidly respond to expression of a given protein, given an unknown target sequence, and also rapidly scale the production of protein to meet national needs. The utility of these manufacturing platforms however can extend beyond protein based vaccines and therapeutics and have proven potential in manufacturing industrial proteins at scale for other DoD applications such as sensors and remediation based technologies. The protein manufacturing process generally consists of two distinct phases: 1) protein synthesis and 2) recovery and purification of the protein of interest from the matrix of the source organism. Although efforts are ongoing to develop alternative expression platforms (recombinant protein manufacturing hosts), often the low cost production of the desired protein ("Upstream" production) does not reduce the "Downstream" costs of manufacturing.

The downstream processing costs typically represent the majority of the expense associated with manufacturing recombinant proteins and can be as high as 60 to 80% of the total manufacturing costs for biologic drugs. These costs can often be prohibitory in development and deployment of a viable countermeasure technology. Current protein manufacturing technology relies primarily on chromatographic resins and other methods which have been used for decades. Ion exchange chromatography, size exclusion chromatography, hydrophobic interaction chromatography, affinity chromatography, and other similar methods are well understood process steps that are

relied upon as workhorses in protein therapeutic manufacturing. While these methods are functionally robust, they tend to be expensive to execute with high material and labor costs and limit the amount of product that can be produced from a single production batch. In addition, the purification materials (resins, etc) themselves can be limited in availability for large scale use without long lead times.

Recent advances have been made in exploring alternative methods, such as aqueous phase separation or self-cleaving affinity tags. Advanced downstream processing technologies that are widely applicable to recovery and purification of a number of protein classes and applications are needed. Preference will be given to biotechnology-based strategies which can supplant traditional chromatographic methods and their associated high labor and material costs. The technology should be applicable to recover and purify proteins from various production hosts and provide significant cost reductions of at least two-fold compared to conventional methods. The technology should also demonstrate ability to scale on demand for use in rapid response manufacturing. The technology must provide purified protein preparations with technical specifications as good as or better than conventional technologies across a range of targets.

PHASE I: Develop a non-synthetic-resin-based protein purification technology capable of recovering and purifying a range of protein products in a manner which meets the technical requirements for the specific proteins-of-interest. Express and purify two (2) different proteins of interest to the DoD at pilot scale using the novel technology and demonstrate purity is comparable or better to that of the same proteins expressed in same expression platform but purified with traditional chromatographic methods.

PHASE II: Demonstrate a cost-effective production technology (2-fold less compared to conventional technologies) for selected protein product targets relevant to the DoD. Demonstrate that the technical efficiency of recovery, protein product quality and cost efficiency of the process are suitable for the protein product. Demonstrate the utility of this process at large scale.

PHASE III: The development of a novel downstream processing technology should complement novel large scale biological expression platform technologies being developed by the DoD to rapidly express proteins of interest for medical countermeasures and industrial technologies. The proposer should identify appropriate transition or collaborative partners who will use this technology in their manufacturing process in expression of proteins that support the warfighter mission. The economic purification of these proteins may also be beneficial in the commercial sector and for Homeland Security.

REFERENCES:

1. Banki, M. R., T. U. Gerngross, and D. W. Wood. 2005. Novel and economical purification of recombinant proteins: intein-mediated protein purification using in vivo polyhydroxybutyrate (PHB) matrix association. Prot. Sci. 14:1387-1395.

2. Boothe, J. G., J. A. Saponja, and D. L. Parmenter. 1997. Molecular farming in plants: oilseeds as vehicles for the production of pharmaceutical proteins. Drug Develop. Research 42:172-181.

3. Wilken, L.R. and Z. L. Nikolov.2011. Recovery and purification of plant-made recombinant proteins. Biotechnol Adv. Aug. 6.

KEYWORDS: downstream processing, bioprocessing, biologics manufacturing, protein purification, chemical, biodefense, pharmaceuticals, medical countermeasures

CBD12-103 TITLE: Design Automation Software for DNA-Based Architectures

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Develop and demonstrate a DNA design automation software package that allows for the specification of large and complex DNA-based architectures. Develop methods to define and manipulate charge and hydrophilicity at the nanoscale.

DESCRIPTION: The folding of single- and double-stranded DNA is a chemically well-understood and controllable process. DNA is generally associated with the storage of genetic information. However, in many ways, it is also an ideal building material. DNA's sequence dictates its shape and structure. Recently, progress has facilitated inexpensive and easy manufacturing of DNA strands with custom sequences. Much of the science of DNA origami is centered on producing better design software. The ability to produce better design software is a critical component of the controlled design and production of large complex structures using DNA origami. There is a need in the chemical/biological defense community to develop new and novel bio-structures. In particular, DNA self-assembly methods have become useful in the mimicry of biological systems such as antibodies and vaccines. In order to mimic biological systems, a DNA origami structure must possess a shape that mimics the antibody or vaccine structure. It needs to also mimic the charge distribution and hydrophobic/hydrophilic nature of a bio-structure at the nanoscale.

To extend DNA origami techniques to bio-molecular applications, the development of simulation tools for defining electrostatic and hydrophilic properties of structure at the nanoscale are needed. In the DNA origami approach, a large DNA structure, such as a plasmid or virus, is tethered together using short strands of DNA that are called "staples". Since every base of the staple DNA strands can be modified, the surface charge distribution on the surface of a DNA origami can be controlled. Likewise hydrophobic and hydrophilic regions can be precisely determined and manipulated. However, current design software packages do not support these needs. Improved design software is needed to support the requirements of the chemical/biological defense community.

Recent advances in the development of evolutionary search algorithms have provided the ability to perform optimizations over sequence design spaces previously thought to be intractable. However, a comprehensive development tool for developing very complex DNA-based nanostructures and architectures still does not exist. An ideal development tool would be able to determine optimal sequence sets according to first principle constraints that are imposed by topology, molecular thermodynamics and self-assembly kinetics. The system would also be able to accommodate designs with up to 30,000 bases and arbitrarily complex pseudo-knots. An ideal system would also address the problem of localized target melting temperatures and would address kinetics as well as thermodynamic issues. A necessary component of a new design tool will be a graphical user interface (GUI) which would allow specification of nanostructure designs, including strand position and topology, designation of the location of non-DNA species in the design and the designation of fixed bases versus variable bases.

PHASE I: Produce a detailed requirements document for a design automation tool that addresses the needs of the chemical and biological defense community in the area of bio-mimicry using DNA origami techniques. In particular, the ability to define charge distribution as well as hydrophilicity and hydrophobicity at the nanoscale should be addressed. The DNA-based design should also address the computational resources that will be required for these applications. Design software that can function in a distributed computing environment is preferred. A description of the core thermodynamics and sequence optimization algorithms should be provided. A distributed, design tool architecture should be proposed that satisfies the usability and computational complexity challenges of the envisioned application. A plan for producing DNA staples with necessary functionality should be addressed. Phase I efforts that also include a corresponding proof-of-concept software demonstration are strongly preferred.

PHASE II: Develop a prototype software application that allows complex nanostructure designs to be specified and automatically populated with optimized sequences. Develop design software that allows for the specification of charge and hydrophilic/hydrophobic structures at the nanoscale. The research and development work should include experimental verification that the resultant sequence sets self-assemble into the targeted designs with high fidelity and yield. The relevance to defense and security applications should be demonstrated through simulation of a bio-molecular structure response. In particular, the problem of molecular recognition should be addressed. Non-covalent bonding to a biomolecule of interest should be modeled and demonstrated. For demonstration purposes, Streptavidin should be used as a target molecule.

PHASE III: Further research and development during Phase III efforts will be directed towards refining a final design, incorporating design modifications based on results from tests conducted during Phase II, and improving the software to meet Chemical and Biological Defense Programs goals and end-user requirements.

PHASE III DUAL USE APPLICATIONS: The new design software will have broad impact across several avenues of defense applications. Once an effective prototype software system is achieved, the system will be amenable to the design of numerous architectures for biological sensing and characterization. Specifically, the software will be a key enabler of sensors having relevance to scientific studies of biological materials, to the detection and identification of biological threats, to medical diagnostics and therapeutics of biological induced diseases, and to the monitoring of commercial consumables for biological contamination.

REFERENCES:

1. Yonggang Ke, Lindsay Stuart, Yung Chang, Yan Liu, and Hao Yan, "Self-assembled water-soluble nucleic acid probe tiles for label-free RNA hybridization assays", Science, volume 319, issue 5860, pages 180-182, 2008.

2. Constantin Pistol and Chris Dwyer, Scalable, Low-cost, Hierarchical Assembly of Programmable DNA Nanostructures, Nanotechnology, volume18, pages 125305/1-4, 2007.

3. Robert M. Dirks, Justin S. Bois, Joseph M. Schaeffer, Erik Winfree, and Niles A. Pierce, "Thermodynamic Analysis of Interacting Nucleic Acid Strands", SIAM Review, volume 49, issue 1, pages 65-88, 2007.

4. Anne Condon and Hosna Jabbari, "Computational prediction of nucleic acid secondary structure: Methods, applications and challenges", Theoretical Computer Science, volume 410, issues 4-5, pages 294-301 2009.

5. P.W.K. Rothemund, "Folding DNA to create nanoscale shapes and patterns", Nature, volume 440, issue 7082, pages 297-302, 2006.

6. Shawn M. Douglas, Hendrik Dietz, Tim Liedl, Björn Högberg, Franziska Graf, and William M. Shih, "Self-assembly of DNA into nanoscale three-dimensional shapes", Nature, volume 459, number 7245, pages 414-418, 2009.

7. Stefan M. Larson, Christopher D. Snow, Michael Shirts, and Vijay S. Pande, "Folding@Home and Genome@Home: Using distributed computing to tackle previously intractable problems in computational biology", Computational Genomics, 2002.

8. Keith Sullivan, Sean Luke, Curt Larock, Sean Cier, and Steven Armentrout, "Opportunistic Evolution: Efficient Evolutionary Computation on LargeScale Computational Grids", Proceedings of the 2008 GECCO conference companion on Genetic and evolutionary computation, pages 2227-2232, 2008.

9. Hongzhou Gu, Jie Chao, Shou-Jun Xiao, Nadrian C. Seeman, "A Proximity-Based Programmable DNA Nanoscale Assembly Line", Nature, volume, 465, pages 202-205, 2010.

10. Wanqiu Shen, Hong Zhong, David Neff, and Michael L. Norton, "NTA Directed Protein Nanopatterning on DNA Origami Nanoconstructs", Journal of the American Chemical Society, volume 131, number 19, pages 6660–6661, 2009.

11. Shawn M. Douglas, Adam H. Marblestone, Surat Teerapittayanon, Alejandro Vazquez, George M. Churchm and William M. Shih, "Rapid prototyping of 3D DNA-origami shapes with caDNAno", Nucleic Acids Research, volume 37, issue 15, pages 5001-5006, 2009.

12. Yonggang Ke, Shawn M. Douglas, Minghui Liu, Jaswinder Sharma, Anchi Cheng, Albert Leung, Yan Liu, William M. Shih, and Hao Yan, "Multilayer DNA Origami Packed on a Square Lattice", Journal of the American Chemical Society, volume 131, number 43, pages 15903-15908, 2009.

13. Ebbe Sloth Andersen, "Prediction and design of DNA and RNA structures", New Biotechnology, volume 27, issue 3, pages 184-193, 2010.

14. Berea A. R. Williams, Chris W. Diehnelt, Paul Belcher, Matthew Greving, Neal W. Woodbury, Stephen A. Johnston, and John C. Chaput, "Creating Protein Affinity Reagents by Combining Peptide Ligands on Synthetic DNA Scaffolds", Journal of the American Chemical Society, volume 131, issue 47, pages 17233-17241, 2009.

15. Dongran Han, Suchetan Pal, Jeanette Nangreave, Zhengtao Deng, Yan Liu, and Hao Yan, "DNA Origami with Complex Curvatures in Three-Dimensional Space", Science, volume 332, number 6027, pages 342-346, 2011.

16. W. A. Hendrickson, "Crystal Structure of Core Streptavidin Determined from Multiwavelength Anomalous Diffraction of Synchrotron Radiation", Proceedings of the National Academy of Sciences, volume 86, pages 2190–2194, 1989.

KEYWORDS: Design Automation Software, DNA Nanotechnology, Nano-Sensor, Antibody, Vaccine

CBD12-104 TITLE: Detection of Liquid Contaminants on Surfaces Using Hyperspectral Imaging

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

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: Develop a hyperspectal imaging standoff sensor for detecting liquid contaminants on surfaces using passive infrared spectroscopy based on cold-sky reflectance.

DESCRIPTION: Surface contamination by CB agents presents a serious threat both to the civilian and military sectors and an adequate defense against these weapons will require rapid detection and identification of both known and unknown agents. Recent measurements in the scientific literature suggest that passive long wave infrared sensors are capable of detecting liquids on the ground by utilizing cold sky reflectance. Cold-sky reflection drives the physics of passive detection of liquids on surfaces. The sky is radiometrically very cold, emitting far fewer infrared photons than objects on the ground. Due to cold sky reflectance, there is an apparent enhanced emission of the resonance bands of the liquid on the ground, which is at ambient temperature. A number of open literature publications have appeared that demonstrate the ability of this technology to detect surface contamination at relevant concentration for the needs of the chemical/biological defense community. A passive infrared approach offers advantages in terms of wide area detection capabilities.

The Joint Chemical Surface Detector (JCSD) program has the goal of detecting liquid and solid chemicals on the ground using noncontact technologies. The system is required to rapidly interrogate the ground to provide wide area standoff detection of chemical warfare agents (CWA) and Toxic Industrial Chemicals (TICs) in real-time. This system has shown the potential to significantly increase the operational speed of the Stryker NBCRV and future reconnaissance vehicles by enabling rapid surface agent detection and identification. Currently the JCSD program utilizes a laser Raman based sensor. The laser system places a small laser spot on the ground. The detection of a chemical contaminant is determined by inelastic scatter from the liquid or solid contaminant. In situations where the contamination is in the form of droplets, this requires that the laser intercept a droplet of contaminated liquid. Also the use of a laser-based detection system raised issues such as eye-safety hazards and high power consumption.

The detection of relevant contaminants on surfaces is challenging because they typically exist in the form of sparse, optically thick droplets with a median mass diameter (MMD) of 0.5 mm or less. Contamination can be as low as 1 droplet per square centimeter and still exceed the objective detection level of 0.5 gram/m^2 that are set for the JSCD. The current laser-based JSCD can easily pass over a contaminated surface without detection due to low probability of intercept of the small laser beam with a small droplet. A false negative can place personnel at risk. A hyperspectral imaging (HSI) approach would significantly increase the probability of intercept with a contaminated droplet on the ground. In the HSI approach, a large area is monitored. A droplet appearing anywhere within the view of the HSI instrument is instantly detected. The false negative rate would be significantly decreased, providing better protection for personnel and equipment.

On-the-move detection of this sparse droplet field is further complicated by the need to collect the signal at short acquisition times and high frame rates in order to avoid spatial and spectral blurring due to vehicle motion as well as increase the probability of particle intercept within the detector's field of view. On-the-move operation requires vehicle speeds as fast as 45 miles per hour. Operating a hyperspectral imager at the very high data rates imposed by this effort will require advances in high speed signal processing and will likely require new algorithm development. It is envisioned that the initial HSI system would use approximately a 1 meter standoff detection distance looking a 30 to 60 degree angle from the vertical and would be positioned in front of the moving vehicle.

It is desirable to extend this technique to longer standoff ranges. Using passive standoff techniques, it should be possible to extend the standoff range to 100 meters or more. Operating at longer standoff distances should be straightforward. Passive detection utilizes cold-sky reflection. The cold-sky reflection provides a constant source term at all distances. However, issues related to slant angle and field-of-view will need to be determined. Larger collection optics may be required at longer distances.

PHASE I: Conduct a feasibility study of detecting liquid contaminants on the ground using a passive long wave infrared hyperspectral imaging spectroradiometer operating in the 8 to 12 μm (micron) region of the electromagnetic spectrum. Perform spectral measurements of a contaminant deposited on concrete, painted metal, grass, and sand surfaces in order to validate the sensor and algorithm models. For this study, a silicone based lubricant should be used. Examine droplets of mission-relevant sizes (~500 μm, micron) on relevant surfaces. Examine the hyperspectral images of surfaces with contaminant present and absent using unpolarized and S-polarized infrared radiation. Develop a system model and the conceptual design of a fast hyperspectral imaging detection system for on-the-move detection. The system should operate in the 8-12 micron region of the spectral region and have necessary spectral resolution to detect chemical agents. The system should assume speeds of operation up to 45 mph with a standoff distance of 1-2 meters and a slant angle of 30 to 60 degrees from the vertical. The system should be able to detect 0.5 mm droplets of contamination on a surface running at these velocities and still provide coverage of a reasonable area in front of the reconnaissance vehicle. Examine issues related to slant-angle, field-of-view, and collection optics. Examine methods for extending the standoff range to larger distances.

PHASE II: Develop a model to describe how well the proposed system will perform. After reviewing the results of the model with the DoD Technical Point of Contact, build a hyperspectral imaging sensor operating in the 8-12 micron region of the spectral region that can operate from a moving vehicle traveling at 45 mph with a standoff distance of 1-2 meters and a slant angle of 30 to 60 degrees from the vertical. The system should have sufficient spectral resolution to detect chemical agents. The system should be able to detect a 0.5 mm droplet of contamination on a surface running at 45 mph and still provide coverage of a reasonable area in front of the reconnaissance vehicle. Develop necessary data acquisition system to provide real-time detection of chemical agents and stimulants. Develop all necessary detection algorithms for real time detection. Demonstrate detection of liquid contaminants on surfaces using a simulant such as a small amount of a silicone oil. Examine the utility of using the sensor at longer standoff ranges. Examine methods for extending the standoff range to 100 meters or more. Issues related to slant-angle, field-of-view, and collection optics should be examined.

PHASE III: Further research and development during Phase III efforts will be directed towards refining a final deployable design, incorporating design modifications based on results from tests conducted during Phase II, and improving engineering/form-factors, equipment hardening, and manufacturability designs to meet the operational requirements of the Joint Chemical and Biological Defense Program, U.S. Army CONOPS and end-user requirements.

PHASE III DUAL USE APPLICATIONS: There are many environmental applications for a sensitive standoff chemical detector/identifier. A rugged, sensitive, and flexible standoff chemical detector will benefit the manufacturing community by providing very finely tuned monitoring of chemical processes. Also, first responders such as Civil Support Teams (CST) and Fire Departments have a critical need for a rugged, versatile, and rugged sensor that can be transported to the field to test for possible contamination by chemical warfare agents.

REFERENCES:

1. J. Thériault, E. Puckrin, J. Hancock, P. Lecavalier, C. J. Lepage, and J. O. Jensen, "Passive Standoff Detection of Chemical Warfare Agents on Surfaces", Applied Optics, volume 43, pages 5870-5885. (2004).

2. J-M. Theriault, C. Bradette, and L. Moreau, “Passive Remote Monitoring of Chemical Vapors with a Fourier Transform Infrared Spectrometer”, Proceedings of the SPIE, Volume 4087 - Application of Photonic Technology 4, pages 962-972. (2000).

3. Roland Harig, Jörn Gerhard, René Braun, Chris Dyer, Ben Truscott, and Richard Moseley, “Remote detection of gases and liquids by imaging Fourier transform spectrometry using a focal plane array detector: first results”, Proceedings of the SPIE, Volume 6378, Chemical and Biological Sensors for Industrial and Environmental Monitoring II, paper 637816. (2006).

4. Thomas A. Blake, James F. Kelly, Neal B. Gallagher, Paul L. Gassman, and Timothy J. Johnson, “Passive standoff detection of RDX residues on metal surfaces via infrared hyperspectral imaging”, Analytical and Bioanalytical Chemistry, volume 395, number 2, pages 337-348. (2009).

5. Jean-Marc Thériault, Hugo Lavoie, Eldon Puckrin, and Francois Bouffard, “Passive Standoff Detection of Surface Contaminants: A Novel Approach by Differential Polarization FTIR Spectrometry”, International Journal of High Speed Electronics and Systems (IJHSES), volume 18, issue 2, pages 251-262. (2008).

6. Roland Harig, René Braun, Chris Dyer, Chris Howle, and Benjamin Truscott, “Short-range remote detection of liquid surface contamination by active imaging Fourier transform spectrometry”, Optics Express, volume 16, issue 8, pages 5708-5714. (2008).

7. A. P. Snyder, J. O. Jensen, W. M. Maswadeh, L. Anderson, B. R. Cosofret, T. E. Janov, H. S. Kindle, D. Konno, R. Miyashiro, and W. J. Marinelli, “AIRIS Remote Detection for Chemical Vapor Clouds: Systems Design and Detection Algorithms”, in Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference and Photonic Applications Systems Technologies, OSA Technical Digest Series, (Optical Society of America), paper JThD74. (2007).

8. Bogdan R. Cosofret, Shin Chang, Michael L. Finson, Christopher M. Gittins, Tracy E. Janov, Daisei Konno, William J. Marinelli, Mark J. Levreault, and Rex K. Miyashiro, “AIRIS standoff multispectral sensor”, Proceedings of the SPIE, Volume 7304, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing X, paper 73040Y. (2009).

KEYWORDS: chemical detection, surface detection, hyperspectral imaging, infrared spectroscopy, high-speed signal processing

CBD12-105 TITLE: Oxygen Storage Technology for Closed-Circuit Self-Contained Breathing Apparatus

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: To develop high-capacity, low-pressure oxygen storage technology for the development of lower maintenance and lighter weight closed-circuit self-contained breathing apparatus with reduced logistical burden.

DESCRIPTION: A Self-Contained Breathing Apparatus (SCBA) is a type of respiratory protection device that provides breathing gas from a source independent of the surrounding atmosphere. A closed-circuit SCBA or “rebreather” re-circulates the breathing air after the carbon dioxide has been removed and the oxygen content restored by either a compressed or liquid oxygen source or an oxygen generating solid. The most common type of non-escape rebreather used in the workplace employ a compressed oxygen cylinder under high pressure to replenish the depleted oxygen in the re-circulated breathing air. The main advantage of a closed-circuit verse an open-circuit SCBA, whereby the breathing gas from a compressed air cylinder is exhaled to the outside, is the extended wear time capable of these devices. Rebreathers have a service life of up to 4 hours whereas open-circuit SCBAs have a maximum service life of only 45 minutes to one hour. However, to achieve their long service life the oxygen cylinder in a rebreather device must be filled to a high pressure (~3000 psi). Special equipment and procedures are

required to safely handle and refill these specially designed high-pressure cylinders. This substantially increases the cost and logistical burden of using these devices.

Novel technology is needed to overcome the shortcomings associated with high-pressure oxygen storage. Innovative oxygen storage solutions are sought that reduce the weight, maintenance, and overall logistic burden associated with high-pressure oxygen cylinders while providing comparable performance in rebreather applications. Potential solutions may include novel physisorptive media (e.g., zeolites and carbon nanotubes), low-power oxygen concentrating technology, or hybrid systems. The goal is to develop a lower maintenance, lower profile, and lighter weight closed-circuit SCBA for unique military operations. Such operations may include prolonged entry into immediately dangerous to life and health (IDLH) atmospheres or unknown CBRN environments.

PHASE I: Develop high-capacity, low-pressure, oxygen storage technology that offers significant improvements in the logistical burden associated with the refilling and handling of high-pressure cylinders. Demonstrate feasibility of proposed enabling technology solution(s) through computer modeling and use of existing empirical data where available. Identify key performance parameters and test criteria relevant to closed-circuit SCBA applications. Establish test set up and procedures to assess and validate proposed approach. Fabricate physical "breadboard" model and conduct bench top testing to characterize the performance of the proposed solution(s) to include but not limited to the following, where applicable to the proposed technology: adsorption capacity, desorption rate, adsorption enthalpy (thermodynamic properties), power requirements, production by-products, and efficiency under relevant temperature/humidity conditions.

PHASE II: Refine and optimize Phase I breadboard model to improve oxygen storage capacity and performance. Perform follow-on bench top evaluations to verify improvements made to the basic enabling technology. Modify test setup and improve test procedures as required. Develop functional scalable prototype by incorporating enabling technology into a suitable test bed (e.g., oxygen storage platform or container). Characterize test bed performance under an operational relevant range of external environmental (temperature/humidity) conditions and in-mask heat/humidity loads. The evaluations should include characterizing the breathing air quality, release of any by-products, exothermic reactions, and other factors relevant to the technology. Based on results obtained, implement necessary refinements to the scalable test bed model.

PHASE III: Fully integrate solution into a full-scale, fully-functional prototype containment unit comparable to the size and weight of a typical rebreather oxygen cylinder. Demonstrate ability of the technology to be incorporated into a fully-functional closed-circuit SCBA through modification of an existing off-the-shelf system. Expand applications to other commercial markets to include industrial and homeland defense closed-circuit SCBAs.

PHASE III DUAL USE APPLICATIONS: Potential alternative applications include firefighting, industrial, mine rescue, and escape SCBAs. Other possible applications include gas purification, gas separation, and underwater breathing devices (SCUBA).

REFERENCES:
1. Tactical Rebreather – TACR." 2011. Technical Products, Inc. 22 Jul 2011 http://www.tpmfg.us/Tactical_Rebreather_TACR.htm>

2. Bliss PL, Atlas CR, Halperin SC. "Portable Oxygen Concentrator." U.S. Patent 7,794,522. 14 Sep 2010

3. Helbig J. "The Missing Link in Personal Escape/CBRN Protection." Homeland Security Today. Ed. David Silverberg. 2009. KMD Media, LLC. 14 July 2011 http://www.hstoday.us/blogs/best-practices/blog/the-missing-link-in-personal-escapecbrn-protection/a88109d77f1864d9c8b78f4ac1f22f7a.html

KEYWORDS: oxygen storage, physical adsorbents, closed-circuit breathing apparatus, rebreather, physisorptive media, gas concentrators, gas storage, SCBA

CBD12-106 TITLE: Carbon Dioxide and Water Removal Technology for Closed-Circuit Self-

Contained Breathing Apparatus

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: To develop high-capacity, low-pressure carbon dioxide removal technology for the development of lower maintenance and lighter weight closed-circuit self-contained breathing apparatus with reduced logistical burden.

DESCRIPTION: A Self-Contained Breathing Apparatus (SCBA) is a type of respiratory protection device that provides breathing gas from a source independent of the surrounding atmosphere. A closed-circuit SCBA or "rebreather" re-circulates the breathing air after the carbon dioxide has been removed and the oxygen content restored by either a compressed or liquid oxygen source or an oxygen generating solid. The most common type of non-escape rebreather used in the workplace employs a compressed oxygen cylinder under high pressure to replenish the depleted oxygen in the re-circulated breathing air. Carbon dioxide is typically removed using an absorbent material such as soda lime. The primary advantage of a closed-circuit verse an open-circuit SCBA, whereby the breathing gas from a compressed air cylinder is exhaled to the outside environment, is the extended wear time capable of these devices. Rebreathers have a service life of up to 4 hours whereas open-circuit SCBAs have a maximum service life of only 45 minutes to one hour. The current carbon dioxide removal process uses an exothermic reaction and does not remove the water produced by the exhaled air. The generated heat is typically removed using ice or re-freezable cooler packs1,2 incorporated into the re-breather system, increasing the weight and logistics. Additionally, the absorbent material cannot be regenerated and must be replaced when expended.

Novel technology is needed to overcome the shortcomings associated with carbon dioxide and water removal. Innovative carbon dioxide and water removal solutions are sought that reduce the weight/size, maintenance, and overall logistic burden associated with currently employed chemical absorbent materials such as lithium hydroxide while providing comparable performance in rebreather applications. Potential solutions may include novel physisorptive media (e.g., zeolites, carbon nanotubes), chemical reactions, or hybrid systems. Efficiency improvements that reduce exothermic heat production over current technologies are desirable. Solutions that also generate oxygen, such as with a KO2 process,3 are acceptable but not required. Technologies that are non-hazardous in use and disposal are desirable. The goal is to develop a lower maintenance, lower profile, and lighter weight closed-circuit SCBA for unique military operations that does not have the heat, size, and weight burden seen in current rebreather systems.4 Such operations may include prolonged entry into immediately dangerous to life and health (IDLH) atmospheres or unknown CBRN environments.

PHASE I: Develop high-capacity, low-pressure carbon dioxide removal technology that offers significant improvements in the logistical burden associated with currently used absorbent materials and ice packs. Demonstrate feasibility of proposed enabling technology solution(s) through computer modeling and use of existing empirical data where available. Identify key performance parameters and test criteria relevant to closed-circuit SCBA applications. Establish test set-up and procedures to assess and validate proposed approach. Fabricate physical "breadboard" model and conduct bench top testing to characterize the performance of the proposed solution(s) to validate improvements to the limitations of current rebreather materials to include but not limited to the following where applicable to the proposed innovative technology: adsorption capacity, desorption rate, adsorption enthalpy (thermodynamic properties), power requirements, production by-products, efficiency under relevant temperature/humidity conditions, and size/weight reductions.

PHASE II: Refine and optimize Phase I breadboard model to improve carbon dioxide removal capacity and performance. Perform follow-on bench top evaluations to verify improvements made to the basic enabling technology. Modify test setup and improve test procedures as required. Develop functional scalable prototype by incorporating enabling technology into a suitable test bed (e.g., carbon dioxide storage platform or container). Characterize test bed performance under an operational relevant range of external environmental (temperature/humidity) conditions and in-mask heat/humidity loads. The evaluations should include characterizing the breathing air quality, release of any by-products, exothermic reactions, and other factors relevant to the technology. Based on results obtained, implement necessary refinements to the scalable test bed model.

PHASE III: Fully integrate solution into a full-scale, fully-functional prototype containment unit comparable to the size and weight of a typical re-breather carbon dioxide absorbent and cooling mechanism. Demonstrate ability of

the technology to be incorporated into a fully-functional closed-circuit SCBA through modification, where feasible and appropriate, of an existing off-the-shelf system. Expand applications to other commercial markets to include industrial and homeland defense closed-circuit SCBAs.

PHASE III DUAL USE APPLICATIONS: Potential alternative applications include firefighting, industrial, mine rescue, and escape SCBAs. Other possible applications include gas purification, gas separation, and underwater breathing devices (SCUBA) for recreational divers.

REFERENCES:
1."BioPak 240R Revolution." 2011. Biomarine, Inc. 31 Aug 2011, http://www.biopak240r.com/

2. "Closed-circuit breathing apparatus Drager PSS BG 4 Plus." 2011. Draeger Safety, Inc. 31 Aug 2011 http://www.draeger.com/media/10/02/44/10024406/pss_bg4_plus_pi_ 9044832_en.pdf

3. "AirElite 4h." 2011. MSA International. 31 Aug 2011, http://www.msa-europe.com/index.php?id=379&L=0

4. Helbig J. "The Missing Link in Personal Escape/CBRN Protection." Homeland Security Today. Ed. David Silverberg. 2009. KMD Media, LLC. 14 July 2011 http://www.hstoday.us/blogs/best-practices/blog/the-missing-link-in-personal-escapecbrn-protection/a88109d77f1864d9c8b78f4ac1f22f7a.html

KEYWORDS: carbon dioxide removal, physical adsorbents, closed-circuit breathing apparatus, rebreather, physisorptive media, gas concentrators, gas storage, SCBA

CBD12-107 TITLE: Continuous Ionization System for Electrostatic Collection of Bioaerosols in Building Protection Applications

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: Develop a system capable of continuous ionization of airborne bioaerosols in the 0.5-5 μm size range that does not generate ozone. The system should be designed for use in electrostatic removal of bioaerosols in HVAC environments at reduced operational costs compared to HEPA filtration.

DESCRIPTION: Continually operating, or "always on," removal of airborne particulates provides not only day-to-day treatment of air in building environments but also provides the most rapid response in the event of a biological contamination event, such as an aerosolized anthrax attack. These systems require no sensors or activation delays since they are already up and running. Systems currently used for high removal efficiency of particulate contaminants are limited to fabric filters and electrostatic precipitation. Filters such as HEPA are effective at removing particles, but induce a large pressure drop (1-6" W.G. depending on loading) that is expensive from an energy standpoint. While electrostatic precipitators are widely used in particulate removal in flue gas streams, typical ionization methods utilize a corona discharge that may generate significant (>10 ppm) levels of ozone which is undesirable in an indoor environment.

Standard air filtration relies on impaction and interception of particles on filter fibers. Prolonged use requires cleaning or replacement of filter media. To achieve high particle removal efficiencies, more tightly woven filters are utilized, increasing energy costs associated with the pressure drop across the filter. Additionally, filters contaminated with biological material are hazardous and must be properly disposed of to avoid spread of contaminants. Ionization-based filtration processes charge particulate matter in the air stream which is subsequently collected by electrostatic precipitation, eliminating the pressure drop associated with fabric filters. Ionization of the airborne particulates is traditionally obtained by corona discharge. However, work funded under a previous SBIR project has demonstrated that an effective ionization region can be established using an electrospray wick array. As with industrial-type electrostatic precipitation systems, it is possible to remove contaminants without the need to directly contact the collection surface, thus eliminating the difficulties associated with disposal of fabric filters.

Electrospray ionization has been used for laboratory chemical analysis and has recently been proposed for incorporation into low-pressure drop air filtration units demonstrating a potential reduction in O&M costs while providing particle removal rates similar HEPA filtration. One significant benefit of electrospray ionization is that ozone is not formed as a byproduct of the process. Rather than direct ionization of particles by an applied voltage difference, electrospray induced ionization of airborne particulates is achieved by charge transfer to the particle from a water based aerosol. Implementation of electrospray into "always on" air filtration applications is currently limited by the lack of reliable, continuous-feed fluid delivery mechanisms for ionization.

Recently, bipolar ionization (BPI) has been demonstrated as an effective method for charging of indoor aerosols, inducing agglomeration and settling of particles, as well as destruction of harmful VOCs. Additionally, BPI has been used as a charging mechanism for a newly designed aerosol time-of-flight mass spectrometer coupled with a differential mobility analyzer and charged plates. BPI can generate high levels of negative and positive ions in an indoor environment without producing ozone and has potential for use in electrostatic precipitation applications.

This topic seeks the development of a novel system for bioaerosol ionization to be used in an electrostatic collection system for building protection applications.

PHASE I: Conduct research on ionization systems that provide uniform and continual delivery of the ions across the entire volume of influent air. The system should be designed for autonomous operation requiring minimal maintenance or user operation (service less than once per month). Additionally, power consumption should be targeted to achieve less than 1.0 watts per cubic feet (35.3 W/m3) of treated air, to align with Department of Defense goals to reduce energy costs. The system should be capable of adapting to treatment of a high concentration spike of bioaerosols that would occur during a biological attack. By the end of Phase I, continual operation of the proposed ionization system should be demonstrated for periods of at least one week without losing effective ionization capabilities or having to replace consumables. The system should be capable of operating for at least two weeks without need for maintenance or replenishing consumables. It should be able to ionize 2,000 particles per cm3 at 50 CFM (1.42 m3/min) to a level adequate for removal of 99.97% of 0.3-1.5 µm (micron) diameter particles in a 20 kV downstream collection region with no measurable ozone generation and minimal temperature increase (<5° C). Particular attention should be paid to ionization of biological particles of this size range using surrogate spores. The specific surrogate to be employed must be proposed and approved by the DoD Technical Point of Contact. It is not necessary to demonstrate the collection region in Phase I.

PHASE II: Design and test a filtration system building upon the ionization concepts developed in Phase I. Technology for electrostatic collection of the charged particles will be explored and tested in combination with the most promising ionization mechanism. Candidate integrated ionization and collection systems should be refined with regards to energy consumption, particle removal efficiencies, ease of operation, and effectiveness in the presence of biological materials contamination in addition to normal particle loadings. Extended duration tests should be accomplished over a variety of temperature and humidity levels. The culmination of Phase II should result in a validated, pilot-scale prototype capable of operation at 2,000 CFM (56.6 m3/min) and a plan for full size scale-up. Effective ionization and collection of surrogate bioaerosols with particle removal efficiencies greater than 99.9% of the 0.3-1.5 µm (micron) size particles should be demonstrated. Additionally, energy consumption in the final system should be favorable when compared to HEPA filtration.

PHASE III: Production of a full size filtration system (> 20,000 CFM [> 566 m3/min]) for demonstration at an DoD installation or other relevant facility. Product performance should be verified to meet the metrics targeted for the bench scale system. At this stage, attention should be paid to parameters such as operational noise, product footprint, and material costs and modifications made as necessary to increase commercialization and manufacturing potential.

PHASE III DUAL USE APPLICATIONS: Electrostatic air filtration technology has potential markets both within and outside of the government for buildings in which there is an elevated threat of chemical and biological contamination. In addition, the technology has the potential to be used in hospitals, schools, and other buildings where high levels of indoor air purification are desired as an alternative to HEPA filtration.

REFERENCES:

1. T. Laitinen et al. “Aerosol time-of-flight mass spectrometer for measuring ultrafine aerosol particles” Boreal Environ. Res. 14, 539-549 (2009).

2. D.P. Greenwood et al. “Optical Techniques for Detecting and Identifying Biological-Warfare Agents” Proc. IEEE., 97, 971-989 (2009).

3. M.S. Zuraimi and K.W. Tham, “Reducing Particle Exposures in a Tropical Office Building Using Electrostatic Precipitators” Build. Environ., 44, 2475-2485, (2009).

4. G. Tepper and R. Kessick, “A study of ionization and collection efficiencies in electrospray-based electrostatic precipitators” J. Aerosol Sci., 39, 609-617 (2008).

5. G. Tepper et al., “An electrospray-based, ozone-free air purification technology” J. Appl. Phys., 102, 113305 (2007).

6. M. Mann, “Electrospray: Its potential and limitations as an ionization method for biomolecules” Organic Mass Spectrometry, 25, 575-587 (1990).

7. R.D. Smith, C.J. Barinaga, and H.R. Udseth, “Improved Electrospray Ionization Interface for Capillary Zone Electrophoresis-Mass Spectrometry” Anal. Chem., 60, 1948-1952, (1988).

KEYWORDS: electrospray, electrostatic precipitation, bipolar ionization, air filtration, ionization

CBD12-108 TITLE: Rapid Sample Transport in Austere Environments

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: To develop advanced, innovative approaches for rapid sample preservation and transport in austere environments. Topic objectives include innovative technologies to enable a low-cost capability to preserve and exfiltrate small medical and environmental biological samples from austere locations and precisely deliver the sample to a pre-determined recovery area. Austere locations are defined as remote and typically inaccessible locations. This capability will be used to exfiltrate medical or environmental samples from an inaccessible area, perhaps with Chemical and/or Biological issues, to enable rapid receipt of physical samples at a laboratory analysis facility.

DESCRIPTION: In austere and inaccessible environments, exfiltration of critical medical, chemical and/or biological samples can be difficult. Lack of maintained infrastructure, inaccessible or remote locations and other factors can limit the ability to transport samples from the area of interest to a location with suitable laboratory facilities.

The Chemical, Biological, Radiological, and Nuclear (CBRN) sample, which will weigh up to approximately two pounds, will need to be packaged to preserve the sample integrity, and then transported distances ranging from 50 to 1000+ miles to a point within approximately commercial Global Positioning System (GPS) levels of precision. Innovative solutions may choose to focus on part or all of this time/distance/weight performance tradespace -- for instance, lighter packages that travel shorter distances, or heavier packages that travel longer distances. At the end of the transport, the sample should be able accurately delivered (commercial GPS-levels of precision) to a pre-determined and/or in-route updated location for recovery by ship or by a ground recovery team. Transport could take as little as 1 hour or as much as 4 days from the time the sample is packaged. The system needs to provide near real-time tracking of the sample from initiation to the final delivery location. Because this system will be used in remote locations and austere environments, a self-contained set-up that can be operated by non-expert personnel after minimal training is required.

For more than 50 years, researchers have defaulted to freezing biological samples at -20ºC or -80ºC as a means of preservation and storage. It is critical to maintain the integrity and quality of nucleic acids for use in downstream

analysis. Using current standards for sample preservation via freezing and shipping with dry ice, proposed approaches would be constrained by a requirement to include in an insulated container approx 7lbs of dry ice for every 24 hours of transport time. Dry ice mass should be calculated to ensure complete sublimation will not occur prior to the package arriving at the destination site. Sublimation is the transition from solid directly to gas since it does not transition from solid to liquid to gas. Storing and preserving the quality of nucleic acids at ambient room temperature would represent a paradigm shift with significant savings in cost, environmental impact and ensured sample integrity. Innovative approaches to room temperature sample preservation may be included in the proposed approaches as a means to extend the performance envelop since this may significantly reduce the size/weight limits and the logistics for obtaining dry ice in austere environments.

The proposed approach should have the following properties:

1) A basic design architecture and a crosswalk between the proposed low-cost design approach and key performance metrics to include end-to-end timeline analysis as a function of payload weight and distance.

2) A basic operational construct matched to the innovations proposed, including proposed or assumed method for sample preservation, transport, precision delivery, and near real-time tracking of the sample from initiation to the final delivery location.

3) A proposed prototype approach that would demonstrate the capability. Identification of any specific Government Furnished Equipment (GFE) associated with future capability demonstration phases to include possible use of Government test sites.

PHASE I: Determine the feasibility of a low-cost rapid sample transport system for use in austere environments. Develop the initial design architecture and a proposed test event for proof-of-concept. Identify key system dependencies and assess global availability of capabilities, like the use of GPS, SATCOM, weather balloons, air corridor restrictions, etc. Develop an initial planning tool to support operational capabilities and limitations for the proposed innovation. For instance, if the proposed transport mechanism uses a low-cost balloon, then given a specific sample collection location, the tool would determine viable destination sites as a function of weather/wind limited by system range, mass, and sample viability timeline restrictions. Down-select to the most promising technologies for further testing in a realistic environment in Phase II.

PHASE II: Design a prototype system that best integrates the proposed components into an optimized system, and demonstrate at least two sample transport events using two different ranges and payload weights. Update the system planning tool to incorporate initial demonstration results.

PHASE III: Develop and perform two overseas field-demonstration for recovery at land and sea locations. Analyze cost-performance trade-offs for low-cost disposable and options for creation of version sets that are releasable and usable by foreign national partners while abiding by International Traffic in Arms Regulations (ITAR) restriction limitations.

PHASE III DUAL USE APPLICATIONS: Enhancements to sample preservation and transportation have wide applications in worldwide medical surveillance, detection and response markets. Other Potential DoD Uses for Technology Innovations: this capability could also be used for the placement of small sensors or unmanned ground systems (UGS) into denied areas. In this situation, the system would be launched from friendly territory, such as a ground location or a boat, and would transport the sensor or UGS into a denied area. Once in the denied area, the system would deliver the sensor or UGS to within ten (10) meters of a desired ground or water location. The system could also be used to measure and transmit atmospheric data to provide real-time weather information via a communications link. Because one operational low-cost construct may be via the use of an altitude adjustable balloon that drifts with the wind and deploys a small guided airdrop system for final delivery, then this system could also be used to return the expensive electronic components of sondes and artillery balloons or commercial weather launch systems to allow for multiple re-uses and to collect weather during assent and descent.

REFERENCES:

1. Lafond, K., et al, “Joint Medical Distance Support and Evacuation Joint Capability Technology Demonstration,” presented at the 21st AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, Dublin, Ireland, May 2011.

2. Yakimenko, O. A., Bourakov, E. A., Hewgley, C. W., Slegers, N. J., Jensen, R. P., Robinson, A. B., Malone, J. R., and Heidt, P. E., “Autonomous Aerial Payload Delivery System “Blizzard”, presented at the 21st AIAA Aerodynamic Delivery Systems Technology Conference, Dublin, Ireland, May 2011.

3. Report of the European Conference on Funding Basic Research in the Life Sciences: Exploring opportunities for European synergies, accessed 13 December 2004,
http://ec.europa.eu/research/health/genomics/funding/bru_aim_en.htm

4. Iyengar GV, Subramanian KS and Woittiez Joost RW, Elemental Analysis of Biological Samples: Principle and Practices, New York: CRC Press, p82, 1997 5. Dutton G, Thinking outside the ice box of DNA, The Scientist 19(14): p28, 2005.

5. Hernandez GE, Mondala TS and Head SR, Assessing a novel room temperature RNA storage medium for compatibility in microarray gene expression analysis, Biotechniques 47(2): pp667-670, 2009 12. Bonnet J, Colotte

6. M, Coudy D, Couallier V, Portier J, Morin B and Tuffet S, Chain and conformation stability of solid state DNA: implications for room temperature storage, Nucleic Acids Res pp1-16, 2009.

KEYWORDS: airdrop, balloons, long range transport, chem/bio sample, sample extraction, long range communication, small package recovery