DEFENSE THREAT REDUCTION AGENCY
12.2 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

The mission of the Defense Threat Reduction Agency (DTRA) is to safeguard the United States and its allies from chemical, biological, radiological, nuclear, and high-yield explosive (CBRNE) weapons of mass destruction (WMD) by providing capabilities to reduce, eliminate and counter the threat and mitigate its effects. The activities described herein are drawn from DTRA's basic & applied research, nuclear technologies, counter WMD technologies, and innovation & systems engineering portfolios. Communications for this program should be directed to:

Defense Threat Reduction Agency
ATTN: Mr. Robert Swahn, SBIR Program Manager
8725 John J. Kingman Drive, MSC 6201
Fort Belvoir, VA 22060-6201
E-mail: dtrasbir@dtra.mil (use of e-mail is encouraged)

The DTRA SBIR program complements the agency's principal technology programs to detect, locate, and track WMD; interdict or neutralize adversary WMD capabilities; protect against and restore capabilities following WMD use; attribute parties responsible for WMD attacks; and provide situational awareness and decision support to key leaders. SBIR topics reflect the current strategic priorities where small businesses are believed to have capabilities to address challenging technical issues. DTRA supports efforts to advance manufacturing technology through SBIR, where the challenges of such technology are inherent to technical issues of interest to the agency.

PROPOSAL PREPARATION AND SUBMISSION

Paragraph 3.0 of the SBIR Program Solicitation provides the proposal preparation instructions. For DTRA Phase I, consideration is limited to those proposals which do not exceed $150,000 and seven months of performance. Proposals may define and address a subset of the overall topic scope. Proposals applicable to more than one DTRA topic must be submitted under each topic.

PHASE I PROPOSAL REVIEW AND EVALUATION

During the proposal review process, employees from BRTRC, Inc., and TASC, Inc., will provide administrative support for proposal handling and will have access to proposal information on an administrative basis only. Organizational conflict of interest provisions apply to these entities and their contracts include specifications for non-disclosure of proprietary information. All proposers to DTRA topics consent to the disclosure of their information to BRTRC and TASC employees under these conditions.

BRTRC, Inc.
8260 Willow Oaks Corporate Drive, Suite 800
Fairfax, VA 22031-4506

TASC, Inc.
8211 Terminal Road, Suite 1000
Lorton, VA 22079-1421

The Technical Point of Contact (TPOC) leads the evaluation process of all proposals submitted in their topics. DTRA will make a determination as to whether the proposal is relevant to the topic solicited. Only relevant topics will be evaluated against further criteria. DTRA will evaluate Phase I proposals using the criteria specified in paragraph 4.2 of the SBIR Program Solicitation during the review and evaluation process. The criteria will be in descending order of importance with technical merit being the most important, followed by qualifications, and followed by the commercialization potential. With other factors being equal, cost of the proposal may be included in the evaluation. DTRA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. However, a DTRA SBIR goal is to provide awards in each Phase I topic solicited.

CONTINUATION TO PHASE II

Only Phase II proposals provided in response to a written invitation from a DTRA contracting officer will be evaluated. DTRA invitations are issued based on the degree to which the offeror successfully proved feasibility of the concept in Phase I, program balance, and possible duplication of other research. DTRA is not responsible for any money expended by the proposer prior to contract award.

Phase II review and evaluation will be similar to the process seen in Phase I. The TPOC leads the evaluation process of all proposals submitted in their topics. DTRA will evaluate Phase II proposals using the criteria specified in paragraph 4.3 of the SBIR Program Solicitation during the review and evaluation process. The criteria will be in descending order of importance with technical merit being the most important, followed by qualifications, and followed by the commercialization potential. With other factors being equal, cost of the proposal may be included in the evaluation. DTRA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

DECISION AND NOTIFICATION

DTRA has a single Evaluation Authority (EA) for all proposals received under this solicitation. The EA either selects or rejects Phase I and Phase II proposals based upon the results of the review and evaluation process plus other considerations including limitation of funds, and investment balance across all the DTRA topics in the solicitation. To provide this balance, a lower rated proposal in one topic could be selected over a higher rated proposal in a different topic. DTRA reserves the right to select all, some, or none of the proposals in a particular topic.

Following the EA decision, the contracting officer will release notification e-mails through DTRA's SBIR evaluation system for each accepted or rejected offer. E-mails will be sent to the addresses provided for the Principal Investigator and Corporate Official. Offerors may request a debriefing of the evaluation of their proposal. Once released, debriefings are viewable at https://www.dtrasbir.net/debriefing/ and require password access. Debriefings are provided to help improve the offeror's potential response to future solicitations. Debriefings do not represent an opportunity to revise or rebut the EA decision.

For selected offers, DTRA will initiate contracting actions which, if successfully completed, will result in contract award. DTRA Phase I awards are issued as fixed-price purchase orders with a maximum period of performance of seven-months. DTRA may complete Phase I awards without additional negotiations by the contracting officer or opportunity for revision for proposals that are reasonable and complete.

DTRA manages SBIR as an ongoing program and does not classify individual Phase I awards as new program starts for the purpose of Continuing Resolution Authority.

OTHER CONSIDERATIONS

DTRA does not utilize a Phase II Enhancement process. While funds have not specifically been set aside for bridge funding between Phase I and Phase II, DTRA does not preclude FAST TRACK Phase II awards, and the potential offeror is advised to read carefully the conditions set out in this solicitation.

Notice of award will appear first on the Agency Website at http://www.dtra.mil. Unsuccessful offerors may receive debriefing upon written request only. E-mail correspondence is considered to be written correspondence for this purpose and is encouraged.

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DTRA SBIR 12.2 Topic Descriptions

DTRA122-001 TITLE: Cost effective, semi-insulating bulk GaN substrates for radiation hard devices

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Investigate and develop a method for cost-effective growth of semi-insulating bulk GaN crystals suitable for use as substrates for radiation-hard electronics and detectors

DESCRIPTION: Nuclear events present major challenges to the continuous, reliable operation of electronics and detectors. A variety of means have been developed to radiation-harden electronics technology, including Radiation Hardening By Design (RHBD), Radiation Hard By Process (RHBP), and the use of wide band-gap semiconductor materials such as GaN and SiC. The former approaches have generally focused on novel uses of otherwise industry-standard processing based on silicon, and therefore are subject to all the limitations inherent to silicon. For example, high frequency amplifiers are generally fabricated on materials such as GaAs or InP that have greatly improved performance characteristics compared to silicon, and devices fabricated on GaN or SiC are being developed as well.

The ideal solution for many classes of devices is to use radiation-hard architectures with a material system that is inherently radiation hard. The best such system appears to be gallium nitride, particularly for devices requiring high frequency operation such as microwave and millimeter wave amplifiers. Indeed, a radiation hard, Schottky-contact-free, GaN-based MOS HEMT has been reported recently [1]. However, like most GaN-based devices being manufactured today, these devices relied on GaN layers grown heteroepitaxially on a non-GaN substrate. It is well known that such layers are highly defective, with threading dislocation densities in the range of 108 – 1010 cm-2, and such dislocations have been shown to markedly degrade the leakage current in HEMT structures [2]. Semi-insulating bulk GaN substrates, grown by hydride vapor phase epitaxy, meeting many of the property requirements for high-performance electronics have been reported [3]. However, the dislocation density of the HVPE substrates remains 10-100× higher than desirable for many electronic and detector applications. In addition, cost is a major challenge: commercially-available 2" diameter bulk GaN substrates typically cost $2000-5000, and 4" and 6" substrates are disproportionately more expensive still and are not yet being manufactured in the U.S.

Native substrates fabricated from bulk single crystals are foundational to virtually all electronics technologies, and the relative immaturity and high cost of bulk GaN crystal technology is a significant impediment to device development. Semi-insulating bulk GaN substrates, with a diameter of at least 100 mm, a room-temperature resistivity of at least 109 -cm, a threading dislocation density below 105 cm-2, and a cost below $500, would greatly improve the nation's ability to develop next-generation, radiation hard electronics and detectors. Successful proposers need to demonstrate a clear path to achieving each of these objectives.

PHASE I: Develop a model that demonstrates that the proposed approach can meet the target cost of $500 for a 100 mm wafer. Synthesize proof-of-concept semi-insulating GaN crystals with a room-temperature resistivity of at least 109 -cm and a threading dislocation density below 105 cm-2. Demonstrate reaction conditions that, upon scale up, would enable achieving the cost target.

PHASE II: Develop a process to implement the proposed improved GaN crystal growth technology, including all necessary ancillary capability. Demonstrate routine capability to synthesize 2" diameter GaN crystals meeting the property metrics under process conditions that can be scaled to meet the cost target.

PHASE III / DUAL USE COMMERCIALIZATION: Military applications will include high power RF amplifiers with high performance and excellent radiation hardness. Commercial applications will include RF amplifiers for cell phone base stations and for high voltage light emitting diodes.

OTHER CONSIDERATIONS: The commercial unavailability of electronic device grade native GaN substrates is an extreme constraint on the large-scale development and implementation of this wide band-gap, high performance, and radiation hard technology. This SBIR has the prospect of leading to an important breakthrough.

REFERENCES:

1. K. Son, “GaN-based high temperature and radiation-hard electronics for harsh environments,” Proc. SPIE 7679, 76790U (2010).

2. S. W. Kaun, M. H. Wong, S. Dasgupta, S. Choi, R. Chung, U. K. Mishra, and J. S. Speck, “Effects of threading dislocation density on the gate leakage of AlGaN/GaN heterostructures for high electron mobility transistors,” Appl. Phys. Express 4, 024101 (2011).

3. P. Gladkov, J. Humlícek, E. Hulicius, T. Šimecek, T. Paskova, and K. Evans, “Effect of Fe doping on optical properties of freestanding semi-insulating HVPE GaN:Fe,” J. Crystal Growth 312, 1205 (2010).

KEYWORDS: Gallium-nitride, radiation-hard, semi-insulating, low-cost

DTRA122-002 TITLE: Develop Circuit Board Assembly Flexible/Formable Polymer Layer(s) with Very High Thermal Conductivity

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Weapons

DESCRIPTION: With advances in Microelctromechanical systems (MEMs) technologies, miniaturized smart munitions have been used in missiles as well as ordnance. The extremely small circuit board assembly (CBA) in these systems is one of the most critical parts of this new generation of smart munitions. However, limitations are being achieved due to the thermal heat budget of the MEMS components. These problems are evident as two types of thermal management issues related to the CBA reliability: (1) CBA thermal management during long-term storage, up-to 15-20 years, sometimes under un-controlled harsh and extreme bunker environments. (2). CBA thermal management during projectile launch – operation, when the board is functional.

In the last four years, DARPA-Microsystems Technology Office has been investigating “Thermal Ground Plane” (TGP) research efforts. An important feature of the DARPA intended TGP technology is to be able to insert this new material(s) easily into existing DoD systems without redesign of those systems. This will provide new engineering heat transfer margins that can be taken up by increasing the power use of the system, reducing the operating temperature of the electronic devices, and reducing the size of the other components of the thermal management system. In addition, the availability of TGPs will allow future DoD electronic system designs to be more aggressive in increases of weapon density, allow for larger power consumption, significantly larger electromagnetic radiation output, and provide greater performance than is presently allowed (Ref 1).

The DTRA is seeking proposals to develop flexible/formable polymer layer(s) to enhance Smart Weapons / Sensor Systems operational survivability. The proposed solution needs to satisfy the following requirements to include: 1) formable polymer layers capable of encapsulating 4" x 8" CBAs with a tight fit for all critical components regardless of shape; 2) formable polymer layer thermal conductivity at less greater than 400 W/m-K (copper thermal conductivity) preferably 800 W/m-K or better; 3) polymer layers will provide EMI protection, attenuation and infiltration; 4) polymer layer will have moisture barrier capabilities; 5) polymer layers need to be compatible with FR4 (fiberglass reinforced printed wiring board material) coefficient of thermal expansion (CTE) and will survive a temperature cycling range (-50 C to 70 C); 6) the upper limit of the polymer layer(s) thickness shall be 0.150 cm; 7) polymer layers will not degrade shock/vibration loads of the existing smart munitions subject to 25K g-force over less than 1 msec duration due to hard target impact (ref. 2).

PHASE I: Proof of concept and development of flexible/formable polymer layer(s) with the required thermal conductivity; EMI shielding and water barrier capabilities. The polymer layer should be capable of encapsulating the complete CBA.

PHASE II: Develop proposed solutions with at least two existing smart munitions applications from AFRL including all necessary experimental test verifications. Present a plan for additional DoD and commercial (dual-use) applications.

PHASE III DUAL USE APPLICATIONS: To be determined based on Phase II progress reports. Based on the research carried out during Phase II, the commercial preparation phase will include a tool made after product sample environmental, shock and vibration, thermal and EMC testing. Test results will provide data needed to finalize material selection, process adjustments and assembly techniques.

UNIQUENESS OF TOPIC: Advances in this work are necessary to enhance weapon survivability for counter weapons of mass destruction operations.

REFERENCES:
1. DARPA "Thermal Ground Plane," http://www.darpa.mil/Our_Work/MTO/Programs/
Thermal_Ground Plane_(TGP).aspx

2. S. Nau "Generation and Measurement of Long Duration High-g Acceleration Profiles," 55th Annual Fuze Conference - Fuzing's Evolving Role in Smart Weapons, Salt Lake City, May 26th 2011. (Slide 4) (www.dtic.mil)

KEYWORDS: Thermal Ground Plane; Circuit Board Assembly; Polymer; High Thermal Conductivity; Concrete Penetration Impact; Extreme High-G Force.

DTRA122-003 TITLE: Chemical Biological Radiological Nuclear (CBRN)-Specific Transformational Materials for Combating Weapons of Mass Destruction (CWMD)

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Sensors, Electronics, Nuclear Technology

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 unique CBRN-specific transformational materials that augment our capabilities to detect individuals and/or materials associated with the development, manufacture, or proliferation of Weapons of Mass Destruction (WMD).

DESCRIPTION: DTRA is exploring innovative technologies for CWMD by developing transformational materials to support Intelligence, Surveillance, and Reconnaissance (ISR) of individuals or materials associated with CBRN weapons technologies and/or products. These technologies will enhance our ability to associate individuals or material with CBRN weapons programs and support DTRA/SCC-WMD's priority of reinforcing the COCOMS and the Department of Homeland Defense capability to rapidly and efficiently respond to WMD threats. DTRA has significant interest in materials that physically transform upon exposure to CBRN agents, isotopes, and their precursors. For example: chemical detection technologies would produce identifiable signatures when exposed to GB, GD, VX, HD or simulants such as DMMP, DIMP, DCH, CEPS and TDG; biological detection technologies would produce identifiable signatures when exposed to anthrax spores; and radiological-nuclear detection technologies would produce identifiable signatures when exposed to radiation from special nuclear materials or medical isotopes, such as Cs-137 or Co-60. Preferably, these materials will be optically covert to the unaided eye before and after transformation, or tailored into a covert key corresponding to a specific library. Ideal solutions would allow an operator to use a currently available imaging/targeting system with/without filters to observe the material after transformation. Ideal solutions would be discernible under both day and night illumination. Emphasis should be placed on signal to noise characteristics to enhance distinguishing a transformational material from its surrounding background. An ideal material would have the potential for the transformational signal to degrade after operationally relevant timeframes. Potential applications for these materials include incorporation into fibers/clothing, solvents, ink, paint, aerosol cans, appliqués, construction materials (concrete, wood, steel, asphalt), and other innovative materials.

PHASE I: Develop and demonstrate in a laboratory environment, transformational materials that possess a detectable signature change when exposed to CBRN agents, simulants, or isotopes, such as GB, GD, VX, HD, anthrax spores, Cs-137, and/or Co-60.

PHASE II: Develop transformation materials and the initial definition of production process controls needed for reliable device performance, as well as quantification of the prototype material sensitivity, specificity, and stability when exposed to CBRN agents or simulants. Characterize and optimize transformational materials for environmental conditions. Conduct a demonstration of a standoff (200 meter) detection capability in an operationally relevant environment.

PHASE III DUAL USE APPLICATIONS: Phase III efforts include transition of this technology and implementation into a variety of uses. Properly designed transformational material would satisfy current civilian safety needs of labor workers in the chemical, biological, or nuclear industry. For example, a worker's clothing could be treated with a material that transforms upon exposure. At the end of the worker's shift, their clothing could be inspected under black light or Infrared IR to determine exposure levels. Civilian infrastructure components could use smart materials embedded into construction materials (concrete, wood, steel, asphalt) to enhance or induce naturally occurring transformation. An example: placing embedded transformational materials in asphalt, capturing natural earth (background) radiation or sunlight during the day and transforming with an associated optical property at night; this ultimately improves roadway visibility. Civilian law enforcement could also use transformational materials by adding/infusing to paint or home products, revealing a stand-off signature of illicit manufacturing labs which threaten homeland security. CBRN-specific transformational materials offer the ability to detect threats before incidents occur and have unique applications with respect to civil sector. This WMD ISR topic supports TTL Program technology requirements and fosters current efforts to expand innovation into C-WMD material applications.

REFERENCES:
1. B. Brownell, Transmaterial, http://www.3dservices.com.au/transformational.pdf

2. B. Brownell, Transmaterial, http://www.eskyiu.com/aainter1/index_files/transmaterial.pdf

3. R. Maxwell, L. Fried, G. Campbell, A. Saab, J. Kotovsky, C. Carter, J. Chang, Materials and Sensor R&D to Transform the Nuclear Stockpile: Livermore's Transformational Materials Initiative, https://e-reports-ext.llnl.gov/pdf/379580.pdf

4. I. Medintz et al., Nature Materials 2, 630–638 (2003).

5. E Goldman et al., JACS 127(18), 6744–6751 (2005).

DTRA122-005 TITLE: Soil-Structure Interaction (SSI) Effects for Fully and Partially Buried Structures

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

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 simplified models to approximate soil effects for fully and partially buried structures.

DESCRIPTION: Computing the response caused by munitions on fully and/or partially buried structures often necessitates using very large finite element (FE) models that include the soil in the structure's vicinity. This is necessary in order to achieve sufficiently accurate results which require approximations for SSI effects, even in the cases of relatively simple structures. Such FE models have been long used in nuclear and conventional weapons effects analyses for buried structures. Soil springs were used to approximate the SSI phenomena and reduce the size of the analytic model. However, there are some problems such as: (1) the soil spring characterization is very dependent upon loading magnitude and frequency, but there is insufficient data and lack of a methodology by which to adequately define this dependency; (2) the need for developing an STF to define the forces hitting the structure based on the motions in the soil that the effects of ground shock and forces imparted to the structure; (3) the influence of arching on the load transfer through the soil, which is related to the relative stiffness of the soil and structure; etc.

Having a simplified soil structure model that appropriately addresses the problems mentioned above would significantly simplify the development of engineering models for fully and/or partially buried structures. Such a methodology would allow the soil effects to be captured without unduly increasing the extent and complexity of the model of the structure, with consideration of frequency effects, nonlinear behaviors (e.g., related to porosity and saturation), and the inherent uncertainties associated with soil behaviors (especially since soil's data in such problems is likely to be sparse).

This proposal looks for characterizing soil effects on the blast and shock response of a structure to reduce computation time in the simulation of underground structures subjected to blast induced shock waves.

PHASE I: Investigate soil material models for their applications to structural analyses under extremely high loading rates such as blast load. Develop nonlinear impedance functions for general geo-materials and evaluate candidate techniques for the introduction of arching effects.

PHASE II: Develop mathematical soil transfer functions (STFs) based on nonlinear impedance functions in closed form following compatibility condition. Compatibility between the FE model and the STF model should address concerns related to discontinuities at the soil-structure interface (e.g., due to arching). Implement mathematical STFs in an existing FE code that should use actual soils data and be validated against results from weapon effects soil-structure tests as a final product of this phase.

PHASE III DUAL USE APPLICATIONS: Incorporate the soil modeling concept (i.e., implemented as a new type of element) for simulating nonlinear soil characteristics under extremely high loading rates into general FE method software. In this implementation, the shape of the element (i.e., the soil-structure module) will be of a form similar to a general shell or solid element. This element would be suitable for incorporation into commercial software, which will allow it to be used widely for the analysis of structural systems where SSI is important. Such a module can also be used for the prediction of ground shock effects due to explosive-based excavations and seismic excitations. The technology developed may also be implemented in the form of a FRM to represent surrounding soil layers with small numbers of element.

REFERENCES:

1. Richard Lane, Benjamin Craig, and Wade Babcock, "Materials for Blast and Penetration Resistance," The AMPTIAC Quarterly, Volume 6, Number 4, pp 39 – 45, ammtiac.alionscience.com/pdf/AMPQ6_4.pdf.

2. Penetration Equations, C. W. Young, October 1997, Contractor Report, SAND97-2426 UC-705, Sandia National Laboratories.

3. An Earth Penetration Modeling Assessment Prediction of Lateral Loading for Oblique Impact Conditions, Technical Report UCRL-TR-213206, Lawrence Livermore National Laboratory, Eugene Stokes, Paul Yarrington, Lew Glenn, June 2005.

KEYWORDS: Penetration, Soil material model, Substructure model, Soil-structure interaction, Buried structure, Tunnel Munitions, Nonlinear soil spring, Transfer function

DTRA122-006 TITLE: <u>Design Combined Effects Explosives (CEX) Using Numerical Simulations</u>

TECHNOLOGY AREAS: Materials/Processes

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 combined effects explosives (CEX) with design guidance from rigorous numerical simulations on detonation and afterburning behaviors of the explosives that provide superior performance in both metal accelerating capability and enhanced blasts.

DESCRIPTION: The Defense Threat Reduction Agency (DTRA) seeks development of new combined effects explosives (CEX) that provide superior performance in both metal accelerating capability and enhanced blasts. DTRA desires that these new CEX formulations be guided and designed by a first-principles numerical simulations that describe detonation, anaerobic reaction (reaction between fuel components and oxidizer components of the explosive after the detonation) and aerobic reaction (reaction between remaining fuel components and the ambient air). The explosive would have at least an equivalent metal acceleration capability of the best current Service certified explosives, while producing 50 % more blast than the best current Service certified explosives.

PHASE I: Development of proof of concept, with design guidance from rigorous numerical simulations and through small scale testing, for a class of combined effects explosives (CEX) that provide superior performance in both metal accelerating capability and enhanced blasts.

PHASE II: Develop, scale up combined effects explosives and demonstrate their technology in prototype weapon configuration demonstrations. Deliverables are a prototype demonstration, experimental data, numerical simulation methodology and analyses.

PHASE III DUAL USE APPLICATIONS: Develop Army, Navy or Air Force explosives to be used in their munitions. Explore drop-in replacement opportunities for use of CEX materials developed in Phase I and II to replace current high explosives used in current inventory weapons. Demonstrate the advantages of the CEP materials over existing high explosives using the modeling capability developed in Phase I and II, with emphasis on the minimization of technical risk due to use of high fidelity predictive capability.

REFERENCES:
1. Kibong Kim and others, “Simulation Guided explosive Formulation,” presented at the 11th Joint Classified Bombs/Warheads & Ballistics Symposium, Monterey, California, August 2009, Distribution C: US Government and its contractors only.

KEYWORDS: combined effects explosives, metal acceleration, enhanced blast, numerical simulations

DTRA122-007 TITLE: Compact High Intensity X-ray Generator and Metastable Inner-Shell Molecular State Warm Dense Matter Research

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Sensors, Weapons, Nuclear Technology

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 new technology for production of high intensity coherent or incoherent soft x-ray beams with high efficiency, based on warm dense matter in so-called Metastable Innershell Molecular State (MIMS).

DESCRIPTION: DTRA is exploring innovative technologies for combating weapons of mass destruction, and wishes to explore use of high intensity x-ray beams, produced by cold compression of hypervelocity nanoparticles, for defeat of chemical and biological threats. X-ray superradiance in nanoparticles has recently been discovered for Metastable Inner-Shell Molecular State (MIMS), a metastable quantum state formed in high energy density materials that are generated under “sudden” compression.[1-3] The x-ray production from MIMS have very distinguished natures compared with thermodynamic (such as in plasmas) or kinetic approaches (such as in Bremsstrahlung process): 1) as much as 40 % of shock energies were observed to convert to x-ray energies, 2) the linewidth of MIMS x-rays is very narrow (< 10 % FWHM). One powerful feature if MIMS is that it appears that any material may be brought to the MIMS condition, which implies that a very large range of x-ray characteristics may be attained. This new soft x-ray production technology may have important counter-WMD applications, as well as other commercial and military applications. Commercial applications for the proposed soft x-ray production technology could include semiconductor, medical, and law enforcement applications. Examples of semiconductor applications include next EUV-soft-x-ray generation lithography that enables construction of smaller scale components on wafers, and highly-efficient cleaning of semiconductor wafer surfaces.[4] For medical applications, the proposed intense directional soft x-ray beams from the proposed method may prove effective to safely and efficiently ablate biological tissues for surgical applications. While this newly discovered understanding of the MIMS state of warm dense matter is encouraging, further research work is needed to develop efficient means for production of MIMS materials. Discovery-focused research is also needed to explore and optimize material choices and to determine which materials will provide the most effective x-ray characteristics needed for countering chem-bio WMD threats. Theoretical work is also needed to explore and explain more deeply the physics of MIMS as it pertains to a large variety of particle and target materials.

PHASE I: Design compact high voltage particle accelerator suitable for attaining MIMS state. For future weapons applications, we have particular interest in use of high explosive and pulsed power techniques for these particle accelerators. Particle velocities in excess of 100 km/s will be needed for desired MIMS states to be achieved. In parallel with the device research, plan to conduct theoretical studies to explore the detailed physics of MIMS and of its effects, so that particle and target materials can be selected for particular x-ray characteristics.

PHASE II: Develop and demonstrate particle acceleration technology designed in Phase I. Conduct experiments to validate and improve the theoretical MIMS physics studies of Phase I, for at least four different particle and target material types. Continue theoretical development for MIMS material states, and extend theoretical development to consider possibility of production of highly intense and directional coherent x-ray beams.

PHASE III: The list of commercial applications that will benefit from the development of this exciting new technology is long and impressive. The proposed soft x-ray production technology can be used in semiconductor, medical, and law enforcement applications. Examples of semiconductor applications include next EUV-soft-x-ray generation lithography that enables construction of smaller scale components on wafers, and highly-efficient cleaning of semiconductor wafer surfaces.[4] For medical applications, the proposed intense directional soft x-ray beams from the proposed method can be used for safely and efficiently ablate biological tissues for surgical applications. In Phase III, conduct market studies to develop these customer bases; determine specific technical requirements for soft x-ray technology that will address these various commercial application areas. Based on these identified requirements, modify the soft x-ray production technologies and choice of starting materials used to produce the MIMS state to optimize the soft x-ray characteristics to adapt them to these various commercial markets. Explore marketing and production alliances with existing technology equipment firms that currently have market share in these various commercial markets. For the military applications, continue the development of the technology and equipment design so that it can be transitioned to a counter-WMD program of record.

REFERENCES:
1. Bae, Y., "Metastable inner-shell molecular state (MIMS)," Physics letters. A, 2008. 372(29): p. 4865-4869.

2. Bae, Y.K., et al., "Detection of accelerated large water cluster ions and electrosprayed biomolecules with passivated solid state detectors," Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 1996. 114 (1-2): p. 185-190.

3. Bae, Y.K., Chu, Y.Y., and Friedman, L., "Observation of enhancement of stopping power and possible hydrodynamic shock behavior in penetration of large molecules in solids," Physical Review A, 1995. 51(3): p. R1742-R1745.

4. Auzelyte, V.et al., J. Micro/Nanolith. MEMS MOEMS 8, 021204 (2009).

5. Kern, W., Handbook of Semiconductor Wafer Cleaning Technology, Noyes Pub., 1993.

6. Boswell, C.J. and O'Connor, P.D., "Charged Particle Motion in an Explosively Generated Ionizing Shock," in Shock Compression of Condensed Matter - 2009 (M.D. Furnish, eds.), pp. 400-403.

7. Voitenko, A.E. and Kirko, V., "Efficiency of a high-explosive plasma compressor," Combustion, Explosion, and Shock Waves, 1975. 11(6): p. 813-815.

8. Voitenko, A.E., "Generation of high speed gas jets," Dokl. Akad. Nauk SSSR, 1964. 158(6): p. 1278-1280.

9. Tasker, D.G., et al., "Electromagnetic effects on explosive reaction and plasma," in 14th International Detonation Symposium - 2010 (B. Asay, eds.).

10. Tasker, D.G., "Design of a Miniature Explosive Isentropic Compression Experiment," in Thirteenth Conference on the Generation of Megagauss Magnetic Fields, Megagauss XIII - 2010eds.).

KEYWORDS: Warm Dense Matter, Shock Waves, X-rays

DTRA122-008 TITLE: Reactive Structural Materials for Enhanced Blasts

TECHNOLOGY AREAS: Materials/Processes, Weapons

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 reactive structural materials (RSM) that will replace steel cases of munitions so that the munitions will generate much stronger blast performance while maintaining a certain degree of penetration capability into targets.

DESCRIPTION: The Defense Threat Reduction Agency desires to develop reactive structural materials (RSM) for increased blast effectiveness of certain munitions. In these conceptual munitions, steel warhead cases are completely or partially replaced with reactive structural material cases. When a steel case is completely replaced by an RSM case, the RSM is expected to have high density and strength enough to allow the munition to be able to penetrate moderate strength targets, such as triple brick walls. When an RSM is not as strong or dense, it can be used together with a somewhat thinner steel case to achieve the same penetration objective as above. Either way, munitions with these RSM cases are expected to generate significantly stronger blast (at least three times stronger) than conventional counterpart munitions with steel cases with a case-mass-to-fill-mass-ratio of 3:1. Low manufacture cost of such RSM is highly desirable.

PHASE I: Development of proof of concept, through small scale testing, for a class of RSM that will allow conceptual munitions with the RSM to generate 3 times as powerful blast while maintaining its penetration capability into triple brick walls.

PHASE II: Develop, scale up RSM and demonstrate its technology in prototype munitions, supported by testing and numerical simulations to the extent possible. Demonstrate that the RSM can be manufactured at low cost. Deliverables are a prototype demonstration, experimental data, a model, numerical simulation technology and substantiating analyses.

PHASE III DUAL USE APPLICATIONS: Develop Army, Navy or Air Force munitions with enhanced blasts and desirable fragment characteristics. Explore drop-in replacement opportunities for use of RSM materials developed in Phase I and II to replace current inert warhead structural materials used in current inventory weapons. Demonstrate the advantages of the RSM materials over existing inert structure through model analyses combined with field and generic target testing of weapon-scale generic warheads followed by tests of new design warheads.

REFERENCES;

1. Figure 7 of William Wilson, LV Benningfield, Kibong Kim, “Blast Effects of Cased Explosives in a Two-Room Structure,” presented at the International Pyrotechnics Seminar, Rotterdam, Netherlands, August 2009

KEYWORDS: reactive structural materials, blast performance, munitions, penetration, low manufacture cost

DTRA122-009 TITLE: Insensitive Munitions Disposal Attack

TECHNOLOGY AREAS: Chemical/Bio Defense, Weapons

OBJECTIVE: Develop a means of causing detonation of Insensitive Munitions (IM) and/or bulk Insensitive High Explosives (IHE) without using large amounts of donor explosives. Device needs to be capable of attacking IM ranging in size from 81mm to missile warheads and bulk explosives in quantities exceeding five pounds.

DESCRIPTION: A means is needed to assist in the disposal of munitions or devices using IHE. Current disposal procedures require excessive disposal charges due to the main charge explosives being made less sensitive to shock. These procedures increase blast overpressure and fragment hazard distances. Additionally, current demolitions materials are shifting to IHE which will make them less sensitive to current demolition initiation methods.

Current 66mm shape charges being pursued may prove impractical in WMD using IHE. Shape charge technology, improved insensitive explosives, and penetration rounds have all shown promise, but none have yet proven to be the answer. Water jet or thermic based technology are also possible answers but have not yet been thoroughly researched or developed. Innovations using described technologies can be a solution to this problem, but other innovative and promising approaches will also be considered. Regardless of the specific approach, the product needs to be man portable and equal to or preferably weighing less than current means; for example, a pound for a projectile and 10 pounds for a larger bomb.

As the Unites States Military and our partners shift to IM and IHE the likelihood for military and civilian personnel to have to dispose of it will only increase. Both civilian and military bomb disposal technicians will be put at a great disadvantage if they have no reliable method to dispose of IM and IHE. Movement to IHE in civilian blasting is currently unknown.

PHASE I: Phase I should conduct studies to develop an item to breech munitions cases and initiate the explosives. Item must show the capability of penetrating munitions/WMD cases of various thicknesses, up to ½ inch, and capable of causing a high order detonation. Low order detonations and/or candle burns are less desirable. The decision to move to Phase II will be based upon likelihood of success based upon computer modeling and/or practical demonstration.

PHASE II: Phase II must develop a prototype of the new tool or unique explosive. Any new explosive items must obtain requisite explosives certification. Item must show consistency in attacking both heavy and thin cased IM of various calibers and configurations. A 10 for 10 level of consistency is the desired outcome against representative projectiles, bombs, and bulk samples. The results should be quantitatively compared to those of existing technologies in the same environments. Existing military/civilian law enforcement initiation systems are the required means of initiation. The Phase II close-out must include a plan for follow-on production and fielding.

PHASE III: Phase III must include identification of support for commercialization of the item to include support from other government entities. Third party verified demonstrations for the DoD and DHS community should clearly demonstrate 99% reliability of the disposal of IM without kick outs. In that this is a disposal tool, cost per use should be kept low (threshold $100/objective $25) and should not require cost prohibitive consumables. Weight and cube of final design must minimize weight and cube while being all weather capable.

REFERENCES:
1. Insensitive Munitions Testing: Protecting Ourselves from our Ammunition
http://www.almc.army.mil/alog/issues/JulAug06/insen_munition_tst.html

2. Insensitive Munitions (IM)
http://www.globalsecurity.org/military/systems/munitions/im.htm

3. Insensitive High Explosives (IHE)

http://www.globalsecurity.org/military/systems//munitions/explosives-im.htm

KEYWORDS: KEYWORDS: ordnance disposal; shaped charge; insensitive high explosive; insensitive munitions

DTRA122-010 TITLE: Intelligent Clothing for Rapid Response to Aid Wounded Soldiers

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Biomedical, Sensors, Human Systems

OBJECTIVE: Develop uniforms with integrated sensors built into the fabric allowing for measurement of overall health, detection of bullet location, detection of exposure to CBRNE (Chemical Biological Radiological Nuclear and Explosive) agents, and communication capabilities to provide location via GPS coordinates as well as critical health assessment information to medical personnel regarding the wounded soldier.

DESCRIPTION: In a situation where a soldier has been hit with either a single bullet or shrapnel from an explosion or has been exposed to CBRNE within their surrounding environment, it is critical to quickly evaluate the vital organs that have been impacted and the life-saving procedures that need to be performed. Current practice involves calling human medics to assess injuries and provide first aid or stabilization. This causes inevitable delay and with CBRNE may prevent first aid.

With Intelligent Clothing, the location of a bullet can be determined with appropriately-embedded sensors within the clothing's fibers that can estimate the depth of penetration and the effected surrounding organs. Additionally, if the person was in an environment where a CBRNE weapon had been stored, manufactured, or used, the Intelligent Clothing could identify the agents via specific biomarkers detected within the blood, saliva, sweat, urine, or could distinguish damage at the cellular, tissue, and/or organ levels post exposure. For example, individuals exposed to a commonly used explosives compound, 2,4,6-Trinitrotoluene (TNT), have been shown to have hemoglobin adducts within their blood and form the urine metabolites of TNT, 4-amino-2,6-dinitrotoluene (4ADNT) and 2-amino-4,6-dinitrotoluene (2ADNT), all of which can be utilized as biomarkers for TNT. In addition, radiation biomarkers include alterations in serum enzyme levels post exposure to ionizing radiation, such as modifications in serum amylase and diamine oxidase concentration levels, which are presently being considered as potential biodosimeters within the medical community. These biomarkers could then be linked to the appropriate array of sensors within the Intelligent Clothing material to detect CBRNE targets, and this information could then be transmitted immediately to emergency responders via communications devices weaved directly into the fabric. This aids in triage and preparation of first responders to be able to handle emergency situations in a critically timely and efficient manner. The collected remotely data would provide commanders venue battlefield awareness as to type of weapons, numbers of casualties and location of engagements.

DTRA requires an assessment of the suitability of various biosensors, communications options and means of integrating these with the appropriate clothing materials and also considering relevant characteristics of the Intelligent Clothing (i.e. – size, thickness, weight, robustness, power requirements, lifetime, as well as sensor sensitivity and selectivity) and the added burdens for the individual troop to manage.

PHASE I: Identify appropriate types of the fabrics, sensors, and related components that are currently available and may be useful for intelligent clothing systems. This phase would also include the selection of biomarkers specific to each agent along with corresponding sensor, and a proof of concept demonstrating operability of components within the military uniform.

PHASE II: Design of selected sensor interfaces and conduct a demonstration of a uniform containing a sensor and communications network.

PHASE III DUAL USE APPLICATIONS: Other applications currently being researched include heart/muscle monitoring for athletes, vitals measurements for babies, and blood sugar levels for Type I and Type II diabetics. Dual Use may be possible for occupations involving hazardous work conditions, mobile diagnostic of life style (as in mobile heart monitors). Furthermore, identification of potential commercial partners and/or commercialization markets in which Intelligent Clothing technology could be transitioned to as an end-user or for further optimization/development.

REFERENCES:
1. http://www.sciencedaily.com/releases/2008/10/081021190640.htm

2. http://www.forbes.com/2007/03/19/hightech-function-clothing-forbeslife-cx_hp_0320smartclothes.html

3. http://www.drugs.com/news/implantable-sensor-measures-blood-sugar-levels-25806.html

4. http://carcin.oxfordjournals.org/content/26/7/1272.full

5. http://www.jpbsonline.org/article.asp?issn=0975-7406;year=2010;volume=2;issue=3;spage=189;epage=196;aulast=Rana;type=0

KEYWORDS: Wearable Sensors, Uniforms, Biosensors, Mobile Communications, Fabrics, Intelligent Uniforms

DTRA122-012 TITLE: Non-Intrusive Filler Identification

TECHNOLOGY AREAS: Chemical/Bio Defense, Weapons

OBJECTIVE: Develop a prototype, stand-off, individual portable, light weight, all-weather, self-powered device to identify the filler of unknown ordnance and suspect devices without opening the case for sampling in order to determine safety precautions, protective measures, and disposal methods while wearing chemical protective clothing.

DESCRIPTION: First responders need the capability to quickly examine suspect items to determine chemical, biological, radiological, and high explosive materials. Any technology that can provide on-site interrogation of suspect material through casings without requiring contact with the material is acceptable. The desired prototype must be capable of being used by personnel with minimum to no training.

The current Portable Isotopic Neutron Spectroscopy (PINS) Systems and the Swept Frequency Acoustic Interferometry (SFAI) are currently not sufficiently ruggedized, require operator training, and are not field upgradeable. However, improvements upon the science of those devices are acceptable.

PHASE I: Must show in a laboratory environment the capability of penetrating munitions/WMD cases of hardened steel or composite materials up to ½ inch thicknesses and classifying the liquid or solid material. 90% identification rate in a lab setting must be capable of identification of both solids and liquids at a full spectrum of ambient operational temperature ranges. In this phase, the device must be able to differentiate generically between explosives, biological materials, radioactive materials, war gasses, and inert materials and provide analysis and read-out to the device operator. A design concept for a prototype that will improve upon current commercially available devices will be a key decision point for continuation to Phase II.

PHASE II: Phase II must develop a prototype device that can be validated independently. The prototype device must show consistency in attacking both heavy (½ inch) and thin cased items (>1/8 inch) of various calibers and configurations. A 9 for 10 level of consistency is the desired outcome in a field setting. Device must be capable of being operated and the interrogation information processed on-site by individuals with minimal training. In this phase the device must be able to differentiate between specific types of explosives, biological materials, radioactive materials, war gasses, and inert materials. The prototype device must also have a field upgradable library to learn new materials as they are encountered. The threshold for the prototype device is 30 lbs. with an objective of 10 lbs. Prototype must be battery operated. Phase II final report should include a development plan for follow-on production and a Phase III roadmap.

PHASE III: Phase III must include identification of support for commercialization of the device to include other government and commercial entities. Third party verified demonstrations for the DoD and DHS community should clearly demonstrate threshold of 95% and an objective of 99% reliability of filler identification. Modification for ruggedization should be carefully undertaken to minimize any increases in weight or cube. Device should be capable of operating using a common battery type and capable of a threshold of 10 samples and objective of 25 samples before the device must be recharged or the batteries replaced. Device cannot require special nuclear licensing or pose a radiation threat if used in a TSA or DHS environment. The device catalog/library must be field upgradable and contain the standard explosives, war gasses, biological materials, toxic industrial chemicals, toxic industrial materials, and radiological materials that are currently of interest to the DoD and DHS. If the device uses a laser, it must be eye-safe. Desired cost of reproducible units is less than $50,000 per copy.

REFERENCES:
1. Chemical Weapons Identification
http://www.ortec-online.com/Solutions/chemical-weapons-identification.aspx

2. A Portable System for Nuclear, Chemical Agent and Explosives Identification
http://www.osti.gov/bridge/product.biblio.jsp?osti_id=792360

3. Swept Frequency Acoustic Interferometry
http://www.remediationweekly.com/premiumacousticinterferometry.html

4. Applications of Swept-Frequency Acoustic Interferometry Technique in Chemical Diagnostics
http://www.osti.gov/bridge/product.biblio.jsp?osti_id=380311

KEYWORDS: KEYWORDS: ordnance, chemical, radiological, biological

DTRA122-014 TITLE: Alternative Signatures for Detection of Radiological and Nuclear Threats

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: We seek proposals to develop radiation detectors of extended range and capability based on the detection of alternative signatures to facilitate the rapid detection and localization of radiological and nuclear threats.

DESCRIPTION: In DTRA’s efforts to interdict Special Nuclear Material (SNM), standoff detection capabilities have the potential to be advanced through the detection of alternative signatures. This mode refers to the detection of a radioactive material by means other than by the direct interaction of gammas or neutrons emitted by the source. Examples include techniques that are capable of exploiting the physical or chemical characteristics of radioactive material (e.g. density, temperature, spectral) or their effect of the surrounding environment (e.g. O3 production via radiolysis, N2 excitation by secondary electrons).

As for one example, when gamma, beta, and alpha radiation interact with the atmosphere produce certain ions and chemicals which, while not providing spectroscopic information about the source, may be more readily detected at standoff than the radiation itself. Radiolytic products such as ozone (O3) and nitrogen oxides (NO and NO2), in particular situations, may be produced in sufficient quantities with lifetimes adequate for detection. Although some of these products may be naturally present in the atmosphere, elevated levels may be indicative of a radioactive source. As such, a study of anticipated signal-to-noise ratios is appropriate.

Techniques with potential for the detection of radiolytics products at standoff include but are not limited to Laser Induced Fluorescence (LIF), Raman Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR) absorption, Differential Absorption LIDAR (DIAL) and passive microwave detection of short-lived elemental hydrogen.

PHASE I: Phase I should conduct a study on the signal-to-noise ratio of the radiolytic products to the natural background. A design concept for a new sensor and demonstrate how it will improve the measurement capability of existing systems with respect to accuracy, false alarm rate and standoff. A clear Phase I to Phase II decision point must be part of the final delivery in Phase I along with a roadmap that takes the program through Phase III.

PHASE II: Phase II must develop prototype sensor that can be validated independently. The results should be quantitatively compared to those of existing technologies in the same environments. Relative cost/benefit studies should be performed to demonstrate the advantages of the new technology. The Phase II final report should include a development plan and partnering approach for follow-on production and fielding along with a roadmap that takes the program through Phase III.

PHASE III: Phase III must include identification of support for commercialization of the sensor system to include other government and commercial entities.

REFERENCES:
1. Knoll, G.F. “Radiation Detection and Measurement” 2rd edition (2000).

2. Tsoulfanidis, N. “Measurement and Detection of Radiation” 2nd edition (1995).

KEYWORDS: KEYWORDS: nuclear detection, radiation detection, special nuclear material, interdiction.

DTRA122-016 TITLE: Tough Nanomaterials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Development of tear-resistant fabrics and heat resistant equipment; development of enhanced materials for C-WMD operations using novel nanomaterial processing techniques.

DESCRIPTION: Recent research has found that using clay nanoparticles to reinforce a polyurethane material makes it 20 times as stiff and twice as resistant to heat. This process uses two solvents, one to disperse the clay nanoparticles and one to dissolve the polyurethane. When the two solvents are mixed, the nanoparticles spread evenly throughout the dissolved polymer. When the second solvent is removed, the clay particles are trapped within the tangle of polymer chains. This process is able to leave areas of the polyurethane flexible, so that the material can stretch substantially without breaking, and the material does not get brittle.

The application of this material would be in the fabrication of tear-resistant clothing for military use, or in the creation of lightweight, resilient packaging. Further, since this material has high heat resistance, it could be used in equipment that is exposed to elevated temperatures. This research is also to investigate of the use of this general processing method to make a wide range of other new elastic materials with enhanced war fighter benefits, such as protection from chemical and biological agents.

PHASE I:
1) Development/adaption of the process for nanomaterial creation, creation of the enhanced polyurethane material using that process, determination of the material properties, and testing the material for use as tear-resistant clothing for military application.
2) Investigation of the possible use in a military environment of the produced materials for their heat resistance properties.

PHASE II:
1) Process optimization for producing materials for specific applications.
2) Test and exercise program to verify and validate the created nanomaterials and end products.

PHASE III: Toughened materials envisioned here could find use in military aviator’s protective flight suites, and naval gun crew protection. When developed it would be attractive for use by civilian firefighters, rescue workers and other first responders.

REFERENCES:

1. "High-Performance Elastomeric Nanocomposites via Solvent-Exchange Processing," Shawna M. Liff, Nitin Kumar, Gareth H. McKinley, Nature Materials 6: 76-83

KEYWORDS: high temperature, nanomaterials, light weight, matrix materials

DTRA122-017 TITLE: 3-D Visualization of Hazard Prediction Plumes

This topic has been removed from this solicitation.

DTRA122-020 TITLE: Real-Time Frequency-Selective Fading Channel Realization Generator

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Sensors, Battlespace, Nuclear Technology

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 real-time implementation of a channel realization generator for frequency-selective fading channels. The channel realizations must take the form of sampled time-varying impulse response functions or time-varying transfer functions. DTRA's Generalized Power Spectral Density (GPSD) currently provides the only statistical formulation of fading channels arising from high-altitude nuclear detonations that is accepted throughout the DoD. DTRA's ACIRF code generates channel realizations characterized by GPSD statistics, and provides DoD's strategic communication and radar communities with a DTRA-approved method of representing disturbed trans-ionospheric propagation channels. DTRA seeks innovative channel realization generator methods that have all of the GPSD-based modeling capabilities of DTRA's ACIRF code, while better serving those applications requiring real-time or higher-speed channel realization synthesis. Such applications include hardware-in-the-loop RF fading channel simulators that test strategic communication and radar systems operating under simulated disturbed-propagation conditions, as well as fast-running software simulations that analyze scintillation-hardened communication and radar system design concepts. To support commercialization, the real-time channel realization generator should be extendable to support the propagation channels exhibiting non-GPSD fading statistics such as those typically employed for testing and analyzing non-strategic communication and radar systems.

DESCRIPTION: DTRA has supported DoD's strategic communication and radar communities by: 1) formulating models of propagation channels disrupted by high-altitude nuclear weapons effects (NWEs) that realistically represent received signal scintillation (i.e., distortion and fading); 2) developing detailed computer simulations to analyze and predict the disturbed-channel performance of strategic RF systems; and 3) developing hardware-in-the-loop fading channel simulators, which have been used for developmental and acceptance testing of strategic RF systems. These research activities have given DoD two important capabilities: 1) the ability to scintillation-harden the design of strategic RF systems; and 2) the ability to test the performance of fielded RF systems under simulated wartime conditions. These capabilities are dependent upon DTRA's fading channel models, the mechanization of which is the subject of this topic.

Time-varying RF channels are assumed to be linear, and therefore can be represented using time-varying complex baseband impulse response functions or transfer functions. The fading channels of interest are assumed to be random, and are described using the statistical characterization presented in Reference 1. DTRA has developed a particular parameterized statistical formulation called the Generalized Power Spectral Density (GPSD), based on Gaussian statistics which characterizes a range of random fading channel models that are appropriate for ionospheric propagation paths disturbed by high-altitude NWEs. The ACIRF code is a software mechanization of the GPSD that also models the filtering effects of the receive antenna. ACIRF generates pseudo-random baseband equivalent realizations of RF fading channels. Both the ACIRF code and its underlying GPSD statistical fading channel formalization are described in Reference 2.

Although the ACIRF code has proven to be a valuable tool, it has limitations. It runs off-line to generate one fixed-length realization that must be stored and repeatedly played back to represent a fading channel over a long time duration. This approach has two drawbacks. First, the fading channel cannot be as well-represented with a repeating fixed-length channel realization update sequence as with an arbitrarily long non-repeating sequence of channel realization updates. Second, any test or analysis application using ACIRF realizations must storage and retrieval capability to accept and playback ACIRF realizations, rather than just accepting a stream of channel realization updates. Also, the fading channel represented by a single ACIRF realization is stationary. Non-stationary channels can only be represented in an ad-hoc fashion by interpolating or other-wise piecing together multiple ACIRF realizations. Finally, ACIRF only generates complex baseband realizations with Rayleigh or Rician amplitude statistics. This is appropriate for the highly-disturbed propagation paths associated with extreme wartime conditions, but not for propagation paths disturbed by natural phenomena such as tropospheric scatter or auroral effects.

The goal of this topic is to identify innovative real-time channel realization generator implementations that can create non-repeating GPSD-based channel realizations exhibiting user-definable non-stationary statistics that become immediately available as needed in real-time or high-speed applications without being stored and retrieved. To enhance commercialization possibilities, the channel realization generator should also support non-Gaussian or non-GSPD-based random fading channel models for the testing and analysis of non-strategic RF systems.

PHASE I: Develop the design of the proposed channel realization generator in sufficient detail to quantify the ranges of decorrelation times, frequency-selective bandwidths, and signal bandwidths for which the proposed design can sustain real-time operation. Also, develop an off-line (i.e., non-real-time) software emulation of the proposed implementation that can create testable channel realization update sequences. Formulate metrics or figures of merit that gauge the fidelity with which the generated channel realizations exhibit GPSD statistics, and provide a direct comparison to realizations created by the ACIRF code. Write a DTRA Certification test plan.

PHASE II: Build the channel realization generator implementation designed during Phase I. Describe how the implementation can be interfaced to or embedded into a high-speed software simulation (such as the COMLNK code described in Reference 3) or the MATLAB Communications Toolkit described in Reference 4 or a hardware-in-the-loop fading channel simulator (such as the Configurable Link Test Set described in Reference 5). Write a detailed operator manual explaining how to use the channel realization generator. Execute the DTRA Certification test plan written during Phase I.

PHASE III: Separate marketing strategies may be required for DoD and commercial applications. For DoD applications, team with software simulation or hardware-in-the-loop channel simulator developers to directly integrate the original GPSD-specific implementation of the channel realization generator into their products. Non-GSPD and possibly even non-Gaussian implementations could be developed for non-strategic RF system testing and analysis.

REFERENCES:
1. Bello, P. A., "Characterization of randomly time-variant linear channels", IEEE Trans. On Comm. Systems, CS 11, Dec. 1963, pp. 360-393.

2. Dana, R. A., ACIRF User's Guide for the General Model (Version 3.5), DNA-TR-91-162, June 1992.

3. Bogusch, R. L., "Digital Communications in Fading and Jamming – COMLNK User's Manual", Mission Research Corporation Technical Report MRC-R-1607A, September 2001.

4. MATLAB R2011a – Communications System Toolbox On-line User's Guide, http://www.mathworks.com/help/toolbox/comm/ug/comm_ug_collection.html

5. Sawyer, B.E., J. T. Reinking and D. A. Wagner, Configurable Link Test Set (CoLTS), WS-R-2010.004, October 2010. (available at http::/www.welkinsciences.com/CoLTSFinalReport)

KEYWORDS: scintillation, fa
ding channel, channel simulation, RF channel simulator, high-altitude nuclear effects