DEFENSE THREAT REDUCTION AGENCY
BROAD AGENCY ANNOUNCEMENT
HDTRA1-14-24-FRCWMD-BAA
Amendment 6
December 2017



Research and Development Directorate (RD)
Chief Scientist and Innovations Department (RD-ST)

Fundamental Research to Counter Weapons of Mass Destruction (C-WMD)

Original Posting Date: March 2015

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OVERVIEW INFORMATION

Agency Name:

Defense Threat Reduction Agency (DTRA)
Research and Development (RD) Directorate
Chief Scientist and Innovation Department (ST)
8725 John J. Kingman Road, MS 6201
Fort Belvoir, VA 22060-6201

Funding Opportunity Title: Fundamental Research to Counter Weapons of Mass Destruction (FRCWMD) Broad Agency Announcement (BAA)

Announcement Type: This is an amended announcement of this funding opportunity. This BAA is in effect from March 2015 through September 2024. It is anticipated that a majority of the actions funded from this announcement will be in the form of grants; however, other instruments such as contracts, cooperative agreements (CAs) or other transactions agreements (OTAs) may also be awarded from this announcement. Submissions for this BAA may occur in two ways: 1) in response to the published topics detailed in Attachment 1 or 2) to a general thrust area as described in Section 1.5.

In general, all topic-specific and general thrust area submissions require pre-coordination in accordance with the guidelines in Section 1.5 and Section 4.2.1. DTRA reserves the right to waive the pre-coordination requirement for topics on a case-by-case basis; and will state the waiver applies within the individual topic description. If a pre-application white paper is received without prior coordination, DTRA may not review it. From the date of the disposition email the applicant has 63 days to submit the pre-application white paper. If the submission is not feasible within this 63-day window, the abstract must be coordinated again to ensure the interest in the white paper remains.

The evaluation of all submissions will be conducted in two phases. Phase I is for receipt and evaluation of pre-application white papers in direct response to a published topic or by invitation based on the assessment of the idea by the Technical POC. Phase II is for receipt and evaluation of invited proposal applications. Invitation to the Phase II, invited proposal submission, will be based on the evaluation results of the Phase I pre-application white paper.

Funding Opportunity Number: HDTRA1-14-24-FRCWMD-BAA

Catalog of Federal Domestic Assistance (CFDA) Number: 12.351

Dates: This BAA is open continuously from March 2015 through September 2024. Published topics will include instructions on any topic-specific opening and closing dates as well as any topic-specific limitations on award types, dollar values, and eligibility. Submissions to a general thrust area may occur at any time this BAA is in effect. Applicants should take care to note requirements for pre-coordination of an abstract.

ADDITIONAL OVERVIEW CONTENT

Research, educational program, or other effort proposals are sought from accredited degree-granting colleges and universities. Research, educational program, or other effort proposals are also sought from industrial, commercial (including small businesses), and not-for-profit research entities. DTRA strongly encourages and may give preference to pre-application white papers and proposals that demonstrate a significant contribution (significant is defined as a minimum of

30% of total value) by one (1) or more universities.

All submissions (pre-application white papers and invited proposals) must be made in accordance with the submission instructions in this BAA through www.grants.gov using the application packages linked with this BAA (under the "Package" tab) on www.grants.gov. Applicants are responsible for ensuring compliant and final submission of their pre-application white papers and proposal applications. Any submission that does not conform to the requirements outlined in the BAA and in the invitation for proposal may not be reviewed or considered further at the discretion of DTRA.

Pre-application white papers may be evaluated any time after receipt. Invitations for full proposal submission may occur any time after the pre-application white paper evaluation and will be limited to available program funds.

Efforts may be proposed for up to five (5) years. Awards may be for a base period of one (1) year with four (4) additional years as possible options, a base period of two (2) years with three (3) additional years as possible options, or a base period of three (3) years with two (2) additional years as possible options. Applicants should take care to propose the most logical mix of base and option years for the scope of work. Further, the base period should yield a logical completion point for the work. In cases where option years are proposed, decisions regarding exercising those options will be based on the evaluation of the work accomplished in the base period. Pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable; however, the Government reserves the right to invite option years for awards that originally only included a base period.

Grants may range from small dollar value (e.g., $25K) up to $1M annually (total, including both direct and indirect costs) depending on the nature and the scope of work. Payments on grants will be made in advance, subject to the conditions described in 2 CFR 200.305. Funding amounts for contracts, CAs, and other procurement instruments will be considered on a case-by-case basis. Thirty (30)-60 individual awards are anticipated each year.

Any assistance instrument awarded under this announcement will be governed by the award terms and conditions, which conform to DoD's implementation of OMB circulars applicable to financial assistance. This includes DoD implementation of OMB guidance in 2 CFR part 200, "Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards."

1. FUNDING OPPORTUNITY DESCRIPTION

1.1. DTRA safeguards America and its allies from weapons of mass destruction (WMD) and provides capabilities to reduce, eliminate, and counter the threat and effects from chemical, biological, radiological, nuclear, and high yield explosives. DTRA seeks to identify, adopt, and adapt emerging, existing and revolutionary sciences that may demonstrate high payoff potential to Counter-WMD (C-WMD) threats, including improvised threats. This BAA is an extramural endeavor that combines the fundamental research, educational program, or other effort needs appropriate for basic or applied research funding of DTRA and other DoD interests.

This announcement solicits ideas and topic-based pre-application white papers for long-term challenges that offer a significant contribution: to the current body of knowledge, to the understanding of phenomena and observable facts, to significantly advance revolutionary technology, to new concepts for technology application, or that may have impact on future C-WMD threat reduction, expertise, or capabilities.

A portion of this effort is expected to be devoted to awards for science, technology, engineering and mathematics education programs with a C-WMD focus; such as, but not limited to postdoctoral fellowships, stipends, degrees, visiting scientist programs, student exchange programs, and development of accredited C-WMD curricula.

1.2. Fundamental research means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.

Contracted Fundamental Research includes research performed under grants, contracts (awards), or OTAs that are (a) funded by budget Category 6.1 (Basic Research), whether performed by universities or industry or (b) funded by budget Category 6.2 (Applied Research) performed on-campus at a university. Fundamental research provides for science and technology (S&T) research and early applied development. It seeks to lower performance risk to a manageable level and facilitate transition and funding to capability end-state programs.

1.3. Technology Readiness Levels (TRLs) provide a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. Fundamental research may be defined within the first four (4) TRLs.

1.4. This BAA seeks optimum approaches to meet DTRA fundamental research objectives. The Government encourages pre-application white papers and proposals that span a wide spectrum of research to expand fundamental scientific knowledge in response to specific topics and to the more general thrust areas. The Government reserves the right to award any combination of approaches which offer the best overall value to the Government and to oversee any and all processes and approaches once ongoing.

1.5. Thrust Areas 1-7 are described below. When a specific set of topics has been identified, these detailed needs will be described in Attachment 1 along with any topic-specific submission instructions, deadlines, anticipated award structure, and funding requirements. Otherwise, pre-application white papers and proposals may be written against one of the general thrust area

descriptions.

DTRA may not review any pre-application white papers without prior coordination of the idea with the appropriate thrust area- e-mail address (Section 7). Applicants should note that there is extremely limited funding available for many of the thrust areas. Pre-application white papers will only be accepted from the coordinated abstracts under limited circumstances.

1.5.1. **Thrust Area 1—*Science of WMD Sensing and Recognition:*** The science of WMD sensing and recognition investigates the fundamental understanding of materials that demonstrate measurable changes when stimulated by radiation or particles from WMD in the environment. This involves the exploration and exploitation of interactions between materials and various electromagnetic phenomena, molecules, nuclear radiation, and particles. Furthermore, these interactions and the specific form of recognition they offer are used for the subsequent generation of information, providing knowledge of the presence, identity, and quantity of material or energy in the environment that may be significant. The goal of this thrust area's portfolio is to advance the following capabilities: location, identification and characterization of radiological-nuclear (RN) materials; detection of RN materials at significant stand-off distances; and the reduction of the technical nuclear forensics timeline. Thrust Area 1 is currently not interested in research focusing on the sensing of explosives or the detection of Improvised Explosive Devices (IEDs).

1.5.2. **Thrust Area 2—*Network Sciences:*** The fundamental science of network sciences includes advancing knowledge of complex disparate but interdependent networks critical to military operations where WMD-related robustness, resiliency, recovery of, and informational and operational utility is required. It includes response, resilience, and recovery of interdependent, multi-layered physical networks after exposure from electromagnetic pulse and other nuclear weapons effects, rapid discovery and analyzing low-observable WMD-related information from large, disparate WMD-related data sets from multiple types of networks, and to develop theories and representations for low observable WMD-related radical ideation from social networks.

1.5.3. **Thrust Area 3—*Science for Protection:*** Fundamental science for protection involves advancing knowledge in physical, biological, and engineering sciences to protect personnel, sensitive electronic systems, and structural infrastructure from the effects of weapons of mass destruction. Protection includes both passive and active defense against threats. Approaches include advanced highly-ordered materials and nanomaterials to hardening infrastructure and facilities against blast, nuclear events, or other CBRNE effects; exploring new methods to experimentally and computationally simulate the effects of a nuclear event; investigations of the interaction of radiation with sensitive electronics and systems as well as development of novel materials and methods that are robust against radiation effects; novel methods to protect personnel from the physical, radiological, and nuclear effects of WMDs; and the study of biological systems, including intact structures, metabolic products, or discrete components and pathways, as applied to protection of U.S. Forces during operations in areas actually or potentially contaminated by radiation. For protection of personnel the areas of interest include development of radiation countermeasures to prevent biological damage associated with exposure to ionizing radiation and development of novel biologically-based or -produced detection systems for wide area surveillance to determine the nature, extent, and distribution of

contamination.

1.5.4. **Thrust Area 4—*Science to Defeat WMD:*** Fundamental science for significantly improving energetic materials for use against WMD facilities and systems with minimal collateral effects from post-blast WMD release, for deeper penetration to deny the adversary sanctuary of WMD, and for predictable modeling of counter-WMD munitions and simulation of in-theater scenarios with accurate lethality calculations.

1.5.5. **Thrust Area 5—*Science to Secure WMDs:*** Fundamental science to support securing WMD includes: revolutionary means to safely handle, transport, control access, or eliminate WMD components and weapons; new physical or other methods to monitor compliance to support future agreements or treaties; and, exploring phenomena and means that facilitate reduction of nuclear or non-nuclear WMD proliferation pathways. This includes focus on: science principles to assist tagging, tracking, location to secure WMD; novel means to mark and read objects in order to secure inventories; remote or unattended monitoring to understand the nature of objects (e.g., is it nuclear, biological, chemical or conventional?); monitoring to detect intrusion, diversion or substitution, tampering, and other adverse activity; and, understanding of both physical and life science environmental signatures as witnesses of WMD-related activity. The ability to secure WMD may impact either verification of treaties, or control of WMD outside treaty regimes.

1.5.6. **Thrust Area 6—*Cooperative Counter WMD Research with Global Partners:*** Cooperative fundamental research to reduce the global threat of WMD in collaboration with a broad range of global research partners. This thrust area involves exploratory basic and applied research that will address opportunities to reduce, eliminate, and counter WMD across the Chemical, Biological, Radiological, Nuclear, and High Explosive (CBRNE) spectrum. Efforts in this area will develop strong international relationships which will foster a smooth transition of program ownership to the partnering country. The goal is to improve international collaboration to detect, characterize, and report WMD, and to advance partner nation sustainment through a culture of long-term cooperation and scientific responsibility for such programs. Multi-disciplinary, multinational research in science, technology, engineering, and mathematics development will be conducted to promote transparency through quality research publications and continual dialogue between scientists/engineers and young researchers.

The Cooperative Biological Engagement Program (CBEP), a component of the DoD Cooperative Threat Reduction (CTR) Program, recognizes the danger to U.S. and global health security posed by the risk of outbreaks of dangerous infectious diseases, whether natural or manmade. Consistent with the national and departmental strategies, CBEP strives to address this risk by promoting best practices in biological safety and security, improving partner country capability to safely and rapidly detect and report dangerous diseases, and establish and enhance international research partnerships that focus on informing the disease surveillance network. The desired end state for CBEP engagements is the development of sustainable partner country capabilities to:

- Employ responsible bio-risk management best practices and principles,
- Conduct a modern and effective disease surveillance mission,
- Independently sustain engagement with, and effectively compete for funding within, the

international scientific community,

- Comply with World Health Organization (WHO) International Health Regulations (IHR) and World Organization for Animal Health (OIE)/U.N. Food and Agriculture Organization (FAO) reporting guidelines, and
- Promote the One Health Concept.

The goals and objectives of CBEP international research partnerships are to:

- Goal 1: Support Biosurveillance, Biosafety and Biosecurity (BS&S) Capability Building Efforts
  - Objective 1: Inform and enhance operational biosurveillance strategies and implementation through improved understanding of endemic disease burden and pathogen biology.
  - Objective 2: Institutionalize responsible biorisk management best practices with partner country scientists.
- Goal 2: Engage Partner Country Scientists in Hypothesis-Driven Research
  - Objective 1: Support local, national, and regional priorities for understanding and mitigating human and animal disease risk (e.g., small, focused projects within individual countries linked by broad, integrating projects that include regional partners).
  - Objective 2: Improve international collaborations to survey, detect, characterize, and report disease.
- Goal 3: Promote One Health Initiative
  - Objective 1: Emphasize the nexus of human health, animal health, and the environment, and seek to further understand the mechanisms and factors involved in disease transmission.
  - Objective 2: Advance partner country sustainment of global health security initiatives.
- Goal 4: Foster an International Culture of Responsible and Ethical Conduct in Biological Research
  - Objective 1: Transition to a culture of responsibility and ethical conduct in biological research through thoughtful experimental design and good laboratory practices that result in high-quality data, and active participation in professional societies and the peer-review process.
  - Objective 2: Train partner country researchers to think critically in the pursuit of ethical research and to be competitive in soliciting funding from the international scientific community.

Ultimately, the techniques, procedures, and approaches must be sustainable for the partner country and linked with appropriate training in order to promote global health security, reinforce norms of safe and responsible conduct, obtain timely and accurate insight on current and emerging infectious disease risks, and transform the international dialogue on biological threats.

CBEP research projects are not determined by or limited to specific biological agents, but must be plausibly linked to pathogens of security concern and aimed at measurably supporting threat

reduction objectives that:

- Enhance partner country's/region's capability to identify, consolidate, and secure collections of pathogens and diseases of security concern in order to prevent the sale, theft, diversion, or accidental release of such pathogens and diseases.
- Enhance partner country's/region's capability to rapidly and accurately survey, detect, diagnose, and report biological terrorism and outbreaks of pathogens and diseases of security concern in accordance with international reporting requirements.

Region-specific areas of interest are described in CBEP Regional Science Plans. Examples of general CBEP research areas of interest include: Epidemiology (e.g. studies measuring disease prevalence and incidence), Pathogen Biology, Pathogen Characterization, Assay Adaptation and Optimization, Microbial Ecology within a Public Health Context, and Preventative Strategies and Countermeasures. For clarification, medical countermeasure development (i.e., development of diagnostic tools, vaccines, therapeutics) is supported by many other U.S. Government or international agencies and is generally not supported by CBEP; however, research projects may inform medical countermeasure development and support validation and verification testing (e.g., as part of proficiency testing, pilot studies/testing, or exercises, etc.). Additionally, CBEP does ***not*** generally support research with common disease agents such as HIV/AIDS, malaria, and tuberculosis where other U.S. agencies have dedicated missions to do so; however, the program may choose to capitalize on opportunities to leverage research on these diseases to further CBEP goals, for example by testing samples collected under the auspices of other programs. CBEP also **will not** support research which poses risks to the overall threat reduction mission of CBEP, Dual-Use Research of Concern, or related activities (i.e., *in vivo* pathogenicity studies, virulence studies, animal passaging, etc.).

CBEP is interested in collaborative research engagements with foreign partners in any one of the following regions: Countries of the Former Soviet Union (FSU) (specifically, Armenia, Azerbaijan, Georgia, Kazakhstan, and Ukraine), Africa (including, but not limited to, Kenya, Tanzania Uganda, South Africa), Southeast Asia (including, but not limited to, Cambodia, Indonesia, Laos, Malaysia, Philippines, Thailand), and Middle Eastern /South Asian countries (including, but not limited to, Afghanistan, Iraq, India and Pakistan). CBEP encourages proposers to develop projects in conjunction with foreign institutions in CBEP-engaged countries.

1.5.7. **Thrust Area 7—*Fundamental Science for Chemical and Biological Defense:*** Fundamental science for chemical and biological (CB) defense includes science and technology research that advances knowledge in physical and life sciences to defend and counter chemical and biological WMD that could be used against our Nation's warfighters. Fundamental research efforts enable capabilities such as development of improved detection devices for traditional and nontraditional chemical agents; development of diagnostics for existing and emerging infectious disease threats; increasing knowledge and improved capabilities for development of new or improved medical and material countermeasures to CB threats for both pre- and post-exposure scenarios; enhanced personal protection against, modeling of, prevention of, or decontamination of CB threats; and providing effective elimination strategies via non-kinetic approaches for threat agent destruction, neutralization and/or sequestration.

1.6. This BAA, in addition to any amendments issued in conjunction with this BAA, will be posted to the Grant Opportunities Website (www.grants.gov), the Federal Business Opportunities

Website (www.fbo.gov), and the DTRA website (www.dtra.mil). The DTRA website is not the official sites; applicants are responsible for monitoring both www.fbo.gov and www.grants.gov. Posted amendments supersede all previous versions of the BAA. Note that topics will be listed in Attachment 1 and will be added/closed with Amendments to this BAA.

1.7. All administrative coordination and communication between applicants and the Government will be conducted using the e-mail address associated with this BAA, specified in Section 7. DTRA will not release employee personal contact information.

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2. AWARD INFORMATION

2.1. Award Types. The full range of flexible procurement instruments available to DTRA are possible results from this announcement, including but not limited to contracts, grants, CAs, and OTAs; however, grants will likely be the predominant procurement instrument. Each of the applicable procurement instruments offer different advantages, liabilities and responsibilities for applicants and the Government.

Applicants must specify in their submittal their recommended approach (e.g. contract, grant, CA, or OTA); however, the Government reserves the right to negotiate and award the types of procurement instruments determined most appropriate under the circumstances. If warranted, portions of resulting awards may be segregated into pre-priced options.

Except for OTAs, the Government actions under this BAA shall adhere to the requirements of the Federal Acquisition Regulation (FAR), Defense Federal Acquisition Regulation Supplement (DFARS) and/or DoD Grant and Agreement Regulations (DoDGARS), as appropriate for the type of instrument. DoDGARs can be accessed online at http://www.ecfr.gov/cgi-bin/text-idx?SID=e5d686f6760f3274b3368f36723fbb7e&mc=true&tpl=/ecfrbrowse/Title32/32CIsubchapC.tpl . See also 32 Code of Federal Regulations (CFR) 22, which can be accessed online at http://www.ecfr.gov/cgi-bin/text-idx?rgn=div5;node=32%3A1.1.1.3.16 . Any assistance instrument awarded under this announcement will be governed by the award terms and conditions, which conform to DoD's implementation of OMB circulars applicable to financial assistance. The current version of the Terms and Conditions for grant awards may be found online in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal).

On average, DTRA expects to award 30-60 individual awards each year. The predominance of awards will be grants. Payments on grants will be made in advance, subject to the conditions described in 2 CFR 200.305.

2.2. Scope of Awards. Awards may range from focused, exploratory projects with a high risk approach in innovative research in subjects with potential for high impact to C-WMD science to comprehensive programs of innovative research in an interdisciplinary area with potential for high impact.

Awards may have multiple Co-Principal Investigators (Co-PIs) and subawards. Authors of pre-application white papers and proposals should detail the contribution of all Co-PIs and any subawards to the C-WMD scientific impact.

Preference will be given to projects where undergraduate and/or graduate students, and/or postgraduate students are supported by the awards. Details regarding the participation of the

students and the value of the research to the students as part of the pre-application white paper and full proposal are expected. Additional guidance regarding student and/or postgraduate student participation may be provided in the published topics or in communications with the applicant to include the coordination of the abstract or in the debrief summary of the pre-application white paper. Any specific guidance provided in a topic or to an applicant supersedes the information provided herein.

2.3. Subawards. Subawards (subgrants and/or subcontracts) are permitted. Subawards may be used to carry out a portion of the research or efforts. Awards may have multiple subawards. Awards will be made by a single award, e.g., grant or contract, to the lead organization. All subawards are the responsibility of the award recipient; exceptions will not be made.

For submissions made to Thrust Area 6 and associated topics, there is no limitation on subawards. DTRA will review and consider the proposed subawards for all pre-application white papers and proposals on a case-by-case basis. The prime awardee will be responsible for transferring funds to the subawardee. Applicants are reminded that priority is given to projects with the main locus of activity in the region-of-interest, so budgets should be allocated accordingly. Preference will be given to proposals where the subaward component to the region-of-interest partner(s) represents more than half of the award value (as measured in U.S. dollars).

2.4. Award Values. Grants resulting from submissions to Thrust Areas 1-7, including topics associated with these thrust areas, may range from small dollar value (e.g., $25K) up to $1M annually (total, including both direct and indirect costs) depending on the nature and the scope of work. Contracts, CAs, and OTAs will be considered on a case-by-case basis. All awards are subject to the availability of funds. Additional guidance regarding award values may be provided in the published topics or in communications with the applicant to include the coordination of the abstract or in the debrief summary of the pre-application white paper. Any specific guidance provided in a topic or to an applicant supersedes the information provided herein. Funding for participation in this program is highly competitive and the cost of proposed research should strictly be maintained as detailed herein or as indicated in the invitation instructions.

2.5. Period of Performance and Award Structure. Efforts for Thrust Areas 1-7, including topics associated with these thrust areas, may be proposed for up to five (5) years. Awards may be for a base period of one (1) year with four (4) additional years as possible options, a base period of two (2) years with three (3) additional years as possible options, or a base period of three (3) years with two (2) additional years as possible options. Additional guidance regarding award structure may be provided in the published topics or in communications with the applicant to include the coordination of the abstract or in the debrief summary of the pre-application white paper. Any specific guidance provided in a topic or to an applicant supersedes the information provided herein.

Applicants should take care to propose the most logical mix of base and option years for the scope of work. Further, the base period should yield a logical completion point for the work. In cases where option years are proposed, decisions regarding exercising those options will be based on the evaluation of the work accomplished in the base period.

DTRA is flexible on the award structure unless otherwise specified in the published topics or in communications with the applicant to include the coordination of the abstract or in the debrief summary of the pre-application white paper. Applicants should take care to clearly label the

tasks and anticipated outcomes for the base and option years in the pre-application white papers and the proposals. Pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable; however, the Government reserves the right to invite option years for awards that were originally awarded with only a base period.

2.6. The Government Accountability Office, in its report GAO-16-14, WOMEN IN STEM RESEARCH: Better Data and Information Sharing Could Improve Oversight of Federal Grant-making and Title IX Compliance, December 3, 2015, recommended that the DoD collect certain demographic and career information to be able to assess the success rates of women who are proposed for key roles in applications in science, technology, engineering, or mathematics disciplines. To enable this assessment, DTRA may include with each application the Research and Related Senior/Key Person Profile (Expanded) form and the Research and Related Personal Data form.

2.7. The Government does not anticipate the need to provide any hardware or software to execute the proposed research. However, DTRA will review and consider any hardware/software requests for all pre-application white papers and proposals on a case-by-case basis.

2.8. The Government reserves the right to fund all, some, or none of the proposals submitted; may elect to fund only part of any or all proposals; and may incrementally fund any or all awards under this BAA. The Government also reserves the right to request applicants make any changes necessary to submitted full proposals to increase the feasibility of making the proposal fundable. Applicants may decline to participate in any revisions to application packages requested by DTRA.

2.9. The Government may offer funding for any full proposals or portions of proposals at any time during the lifetime of this BAA.

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3. ELIGIBILITY INFORMATION

3.1. Pre-application white papers and proposals submitted for this BAA will be considered from the following U.S. and Foreign Institutions as follows:

- Accredited degree-granting colleges, universities, and academic institutions.
- Industrial and commercial entities, including small businesses.
- Not-for-profit entities with a portfolio predominantly in research and foreign government laboratories. Proof of 501(c)(3) status from the Internal Revenue Service may be required. For foreign-based establishments entirely based outside the U.S. and/or its territories, proof of not-for-profit status may be required. Foreign based government laboratory equivalents include those residing in the Ministry of Defense, Ministry of Health, Ministry of Agriculture, Ministry of Education and Science and Food Safety Agencies.

DTRA strongly encourages and may give preference to pre-application white papers and proposals that demonstrate a significant contribution (significant is defined as a minimum of 30% of total value) by one (1) or more universities. Applicants should note that university participation may be mandatory for some published topics. Additional guidance regarding

university participation may be provided in the published topics or in communications with the applicant to include the coordination of the abstract or in the debrief summary of the pre-application white paper. Any specific guidance provided in a topic or to an applicant supersedes the information provided herein.

The following entities may not participate as prime awardees nor furnish Principal Investigators (PIs) in awards made under this BAA but may act as collaborators, including as Co-PIs, and/or subawardees:

- Federal Academic organizations (e.g., Naval Postgraduate School).
- Federal laboratories (including DoD and Department of Energy (DOE)).
- U.S. Government agencies.
- DoD-sponsored Federally Funded Research and Development Centers (FFRDCs) specified in the Defense Federal Acquisition Regulation Supplement (DFARS) 235.017-1 (http://farsite.hill.af.mil/VFDFARA.HTM) and click on 'DFARS Part 35'.
- DOE-sponsored FFRDCs.

Note: Federal laboratories (including DoD and DOE) and FFRDCs are eligible to submit abstracts (when required), pre-application white papers, and proposals in response to the Government Call issued by the DTRA Chief Scientist and Innovations Department. However, a FFRDC (other than the DoD FFRDCs specified in DFARS 235.017-1) must have authorization from its sponsoring agency in accordance with FAR 35.017-1. Eligibility requirements under the Call are subject to change. See http://www.dtrasubmission.net and after logging in, follow the link to the 'FY12-17 Fundamental Research to Counter Weapons of Mass Destruction (C-WMD) Government Call'.

3.2. Cost Sharing or Matching. In general, cost sharing or matching is not required for applications to this announcement. However, DTRA reserves the right to require cost sharing or matching on a case-by-case basis. Such instances will be specifically detailed in the published topics or in communications with the applicant to include the coordination of the abstract or in the debrief summary of the pre-application white paper.

3.3. Other. DTRA uses the System for Award Management (SAM) to exclude recipients ineligible to receive Federal awards. SAM can be accessed online at http://sam.gov (Reference 2 CFR 1125).

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4. APPLICATION AND SUBMISSION INFORMATION

4.1. Address to Request Application Package. This announcement contains all information required to submit a pre-application white paper and invited proposal. For convenience, Microsoft (MS) Word and MS PowerPoint templates for Phase II proposal submissions are provided in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal) for applicant use. Applicants are encouraged to use the templates for preparing submissions; however, use of the templates is not required. Note: there is not a template available for the pre-application white paper.

4.1.1. The required application packages for the pre-application white papers and for the invited

proposals are posted with this announcement. Note that each thrust area (as outlined in Section 1.6) and each topic (as outlined in Attachment 1) has a unique application package posted with this BAA. The application package corresponding to both: a.) the thrust area or topic of interest and b.) the phase, should be used for submission of pre-application white papers and invited full proposals.

4.1.2. The application packages posted to www.grants.gov consist of the forms as detailed in Table 2.

Form Name	Phase I Pre-Application White Paper	Phase II Invited Proposal
SF-424 (R&R) Application for Federal Assistance Form	Required	Required
RR Budget Form	N/A	Required
R&R Subaward Budget Attachment(s) Form(s)	N/A	If Applicable
Research & Related Senior/Key Person Profile Form	N/A	Required
Research & Related Other Project Information	N/A	Required
Disclosure of Lobbying Activities (SF-LLL)	N/A	If Applicable
Attachments Form	N/A	Required

Table 2: Forms. The instructions for completing each of these forms may be found online at the following web link: http://www.grants.gov/web/grants/form-instructions.html.

4.2. Content and Form of Application Submission. Submissions for this BAA will be conducted in two phases. Phase I is for receipt of pre-application white papers. Phase II is for receipt of invited proposal applications. Invitation to the Phase II proposal submission will be based on the evaluation results of the Phase I pre-application white paper.

4.2.1. The predominance of efforts, including all submissions to the thrust areas and most submissions to topics posted in Attachment 1, **must be** coordinated with the relevant technical point of contact (POC) for the appropriate thrust area prior to submission of a pre-application white paper; an e-mail for the DTRA technical POCs for Thrust Areas 1-7 are provided in Section 7. Coordination of research ideas and efforts must be accomplished via these email addresses, except in cases where a topic specifically states that pre-coordination is not required, and includes submission of an abstract (recommend less than 250 words) of the proposed project/effort or a paragraph description of the proposed project/effort to the email address in Section 7 and a reply email from the relevant email address in Section 7 with the disposition to the applicant. Pre-coordination may not be accomplished with email addresses other than those listed in Section 7. DTRA may not review white papers without prior coordination. Please note that attachments to e-mails may not be reviewed.

Applicants should note that there is extremely limited funding available for the general thrust areas. Pre-application white papers will only be accepted from the coordinated abstracts under

very limited circumstances.

Topics may be posted in Attachment 1 of this announcement that may not require pre-coordination of an abstract. Please review the topics carefully.

4.2.2. Pre-application white papers and invited proposals **must be** submitted electronically using www.grants.gov and the corresponding application packages linked with this BAA on www.grants.gov (under the "Packages" tab). All applications, including all supporting documents, must be submitted in the English language.

Applicants are responsible for ensuring compliant and final submission of their Phase I pre-application white paper and Phase II invited proposal application. Note that this also applies to applicants using third party systems to submit application packages and attachments. Any submission that does not conform to the requirements outlined in the BAA and in the invitation for proposal may not be reviewed or considered further at the discretion of DTRA.

4.2.3. DTRA will not review any of the following:

- Pre-application white papers that are not pre-coordinated as required
- Pre-application white papers and proposals that are not submitted in the English language.
- Pre-application white papers that are submitted to topics that have been previously closed via an amendment to the BAA.
- Application packages and proposals for Phase II submissions that were not invited.

Exceptions WILL NOT be made under any circumstances.

4.2.4. Phase I Pre-Application White Paper Submission and Content.

Each pre-application white paper must address only one thrust area or topic. Each pre-application white paper must use the corresponding thrust area or topic application package.

Each Phase I application package contains the following forms:

Form	Attachment	Action
SF-424 (R&R) Application for Federal Assistance Form	Up to four (4) page white paper	Enter the appropriate information in data fields

Table 3: Phase I Pre-Application White Paper Package Chart.

Each Phase I application package contains the SF 424 (R&R) Application for Federal Assistance. To be considered a complete package, an up to four (4) page white paper is required to be uploaded as an attachment to the SF 424 (R&R).

DTRA-specific instructions for completing the SF 424 (R&R) Application for Federal Assistance are below, general application instructions can be found on www.grants.gov:

- Block 1 – Type of Submission. Applicants should indicate the Phase I submission is a "Pre-

Application."

- Block 2.1 – Applicant Identifier. Not applicable.
- Block 3 – Date Received by State. Not applicable.
- Block 3.1 – State Application Identifier. Not applicable.
- Block 5 – Applicant Information. You must provide a Business Office Point of Contact (BPOC) with an e-mail address.
- Block 19 – Authorized Representative. The "signature of AOR" is not an actual signature and is automatically completed upon submission of the electronic application package. Hard copies or email attachments of applications will not be accepted.
- Block 20 – Pre-application. Must be used to attach an up to four (4) page white paper. The white paper itself should provide sufficient information on the research being proposed (e.g., the hypothesis, theories, concepts, approaches, data measurements and analysis, etc.) to allow for an assessment by a technical expert.

Any pages submitted for the white paper that exceed the limit of four pages will not be read or evaluated. A page is defined as 8 ½ x 11 inches, single-spaced, with one-inch margins in type not smaller than 12 point Times New Roman font. The white paper must be provided in portrait layout.

At minimum, the white paper should address the following:

- A project abstract, which should be concise (less than 250 words), provide a summary of the proposed work, and demonstrate relevance to the topic being addressed. The abstract should not contain any proprietary data or markings.
- Potential scientific impact to provide greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts, including how the research contributes to the C-WMD science needs outlined in the thrust area or topic.
- The impact of the research on C-WMD science must be clearly delineated.
- Cost estimate by year and total dollars required to accomplish the research as presented in the white paper (no details or breakout of costs is required).
- Potential team and management plan, including details on student involvement.
- Multidisciplinary white papers should carefully detail each of the institutions/departments involved and the contribution that will be made by each of the investigators.
- Do NOT include corporate or personnel qualifications, past experience, or any supplemental information with the white paper. References may be included within the 4-page limit at the discretion of the applicant; however, extensive references are not required.
- Thrust Area 6 pre-application white papers must also include a description of the extent and duration of the relationship/collaboration between the universities/institutes/entities and/or scientists.
- The thrust area or the topic should be included as a header on the white paper attachment and

referenced in the text of the white paper.

4.2.5. Phase I Pre-Application White Paper Re-Submission and Content.

On a limited basis a second pre-application white paper may be submitted without pre-coordination of an abstract. These re-submissions will be based on the review of the original pre-application white paper and will be allowed when changes to the project scope, technical approach, and/or cost are envisioned for any potential full proposals. Revised pre-application white papers must conform to the standards for the pre-application white papers detailed in Section 4.2.4.

All submissions should be made with the appropriate Phase I application package which contains the following form:

Form	Attachment	Action
SF-424 (R&R) Application for Federal Assistance Form	Up to four (4) page white paper	Enter the appropriate information in data fields

Table 4: Phase I Pre-Application White Paper Package Chart.

Each Phase I application package contains the SF 424 (R&R) Application for Federal Assistance. To be considered a complete package, an up to four (4) page white paper is required to be uploaded as an attachment to the SF 424 (R&R).

The DTRA-specific instructions for completing the SF 424 (R&R) Application for Federal Assistance are the same as for the original pre-application white paper submission except for the following:

- Block 1 – Type of Submission. Applicants should indicate the Phase I re-submission is a "Changed/Corrected Application."
- Block 4c – Previous Grants.gov Tracking ID. Enter the Phase I Grant ID for the original submission.

At minimum, the revised white paper should address the issues and questions detailed in the debrief summary.

4.2.6. Phase II - Invited Proposal Submission and Content.

Each proposal must address only the thrust area or topic for which it was invited. The application package corresponding to the thrust area or topic of interest should be used for submission of invited full proposals.

Each Phase II application package contains the following forms and attachments:

Form	Attachment	Action
SF-424 (R&R) Application for Federal Assistance Form	*N/A*	Enter the appropriate information in data fields
RR Budget Form	Budget Justification for entire performance period	Attach to Section K in budget period one
RR Subaward Budget Attachment(s) Form (*if applicable*)	Individual subaward budgets	Attach a separate budget with justification for each subaward
Research & Related Senior/Key Person Profile Form	PI Biographical Sketch	Attach to Biographical Sketch field
	PI Current/Pending Support	Attach to Current & Pending Support field
	Key Personnel Biographical Sketches	Attach to Biographical Sketch field for each senior/key person
	Key Personnel Current/Pending Support	Attach to Current & Pending Support field for each senior/key person
Research & Related Other Project Information Form	Publically Releasable Proposal Summary/ Abstract	Attach to Block 7 Project Summary/ Abstract
	Project Narrative/Technical Proposal	Attach to Block 8 Project Narrative
Disclosure of Lobbying Activities (SF-LLL) *(if applicable)*	*N/A*	*N/A*
Attachments Form	Attachment 1 – SOW	Upload as Attachment 1
	Attachment 2 – Quad Chart	Upload as Attachment 2
	Attachment 3 – Supporting Documentation (Thrust Area 6 submissions only)	Upload as Attachment 3

Table 5: Phase II Proposal Package Forms and Attachments.

DTRA reserves the right to consider incomplete application packages and required attachments and to request any missing information via email. Should the applicant fail to provide all the requested information either as part of the www.grants.gov submission or in response to email requests from DTRA, at their discretion, DTRA may not consider the proposal further.

SF 424 (R&R) Application for Federal Assistance: DTRA-specific instructions for completing the SF 424 (R&R) are below. General application instructions can be found on www.grants.gov:

Block 1 – Type of Submission. Applicants should indicate the Phase II submission is an "Application."

Block 2.1 – Applicant Identifier. Not applicable.

Block 3 – Date Received by State. Not applicable.

Block 3.1 – State Application Identifier. Not applicable.

Block 4b – Agency Routing Identifier. Enter the corresponding Phase I Grant ID. If resubmissions were involved, enter the Grant ID for the last submission.

Block 5 – Applicant Information. You must provide a Business Office Point of Contact (BPOC)

with an e-mail address.

Block 19 – Authorized Representative. The "signature of AOR" is not an actual signature and is automatically completed upon submission of the electronic application package.

RR Budget Form: The Research and Related Budget Form provided as part of the application package for the Phase II submission should be filled out in its entirety for each project year proposed. Applicants are responsible for ensuring appropriate, approved rates are used in their budget forms. When notified of selection applicants will be requested to provide their current rate agreement and the rate agreement of their subcontractor(s), if applicable. Applicants should note that in accordance with 32 CFR 22.205(b), grants shall not provide for the payment of fee or profit to the recipient.

Applicants should plan and budget for travel to accommodate the two meetings outlined below:

- National Conferences/Workshops/Symposia: Applicants are strongly encouraged to attend a nationally recognized conference, workshop, or symposium in the field of research each calendar year (1 at minimum). Research should be presented as soon as adequate data are available to support posters and presentations. Conferences/workshops/symposia should be attended by the PI and students supporting the research, as appropriate.
- Annual Technical Review: Applicants should plan to attend an annual technical program review meeting. For planning purposes the review will be for five days and will be held in Northern Virginia.

Budget Justification: Applicants are required to submit a budget justification. The budget justification should be prepared as outlined in the instructions for the Research and Related Budget and uploaded as an attachment to Section K "Budget Justification" of the Research and Related Budget Form. The budget justification does not have a page limit, but should include sufficiently detailed information for meaningful evaluation. In addition, the budget justification must specifically address subaward costs and type to include the portion of work to be subawarded with a supporting rationale. The budget justification should include a discussion of how the subawardee(s) cost was determined to be fair and reasonable.

RR Subaward Budget Attachment(s) Form (if applicable): Detailed cost estimates are required for each proposed subaward. The cost estimate for the subawards should include sufficiently detailed information for meaningful evaluation, including labor rates and indirect cost rates.

Research and Related Senior/Key Person Profile Form: The Research and Related Senior/Key Person Profile Form should be completed in its entirety for each of the PIs and Co-PIs on the project. The inclusion of additional personnel is at the discretion of the PI. For Thrust Area 6 submissions, the PI (and Co-PIs) in the region-of-interest should be included as key personnel.

A biographical sketch is required for each PI and Co-PI on the project. DTRA does not have a preference for the format of the biographical sketch; however, it should be limited to 1 page per person. The biographical sketch should be uploaded as an attachment to the corresponding field on the Research and Related Senior/Key Person Profile Form.

Additionally, a statement of current and pending support must be provided for each PI and Co-PI on the project. This statement should include a summary of the current and pending support of related work and requires disclosure of all grants and contracts through which each PI and Co-PI

is currently receiving or may potentially receive financial support.

Research and Related Other Project Information Form:

Block 7 – Project Summary/Abstract. To fulfill the requirements of Section 8123 of the Defense Appropriations Act, which states: "The Secretary of Defense shall post grant awards on a public Web site in a searchable format," DTRA will collect and post via the Defense Technical Information Center (DTIC) basic information about all awards made under this BAA. The information posted will include the abstract submitted to Block 7 of this form.

The uploaded project abstract should be less than one page and provide a summary of the proposed work and demonstrate relevance to the topic being addressed. Most importantly, the abstract **must be** written such that the general public may easily understand the potential scientific contribution and the impact of the research. The header of this uploaded document must contain the following statement:

> *"This publically releasable abstract is provided to DTRA for use in fulfillment of Section 8123 of the Defense Appropriations Act and future versions of the same."*

The abstract absolutely must not contain any proprietary data or markings.

Block 8 – Project Narrative (Technical Proposal). The uploaded technical proposal must not exceed 20 pages (including references). If the proposal exceeds 20 pages, only the first 20 pages will be reviewed. A page is defined as 8 ½ x 11 inches, single-spaced, with one-inch margins in type not smaller than 12 point Times New Roman font. The technical proposal must be provided in portrait layout. A template for the technical proposal format may be found online in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal) (MS Word format).

The project narrative (technical proposal) must include the following components:

- ***Abstract.*** Should be a technical project abstract that is distinct from the Project Summary/Abstract that is attached to Block 7.
- ***Scope.***
- ***Objective.*** A clear and concise objective of the proposed project.
- ***Background.*** Provide the necessary technical and scientific background to support the scientific and/or technical merit of the proposed project.
- ***Programmatics.*** Describe your organization's management plan for the proposed project; list supporting and collaborating centers, and the roles/responsibilities of each identified academic and/or industrial subcontractor supporting the project. Authors of multidisciplinary proposals must take great care to clearly outline the impact to C-WMD science that is to be gained from the investment and justify the scientific contribution from each investigator.

  Thrust Area 6 narratives must also describe of the extent and duration of the relationship/collaboration between the universities/institutes/entities and/or scientists. Teams with pre-existing collaborative research relationships and those which propose to establish new collaborations will be considered, provided teams can supply documentation to demonstrate that an operational framework exists to support the proposed work. Please see

Attachment 3 below for information on the submission of this documentation.

- ***Relevance.*** Describe the relevance of the proposed project in terms of advancing the state of the science and the anticipated scientific impact on capabilities to potentially reduce, eliminate, counter, provide greater knowledge or understanding of the threat, and mitigate the effects of WMD fundamental aspects of phenomena and of observable facts.
- ***Credentials.*** Describe the PI's qualifications and the organization's qualifications to perform the proposed work. Summarize the credentials of the primary performing center, and supporting academic and industrial partners to perform the work. Describe specific examples of equipment and/or facilities available to perform the proposed work. Focus on information directly relevant to the proposed work.
- ***Work to be Performed.*** Provide details of the work to be performed by task and subtask. Tasks must be grouped by project year; base and option years should be clearly labeled. Additional details that are required include the following:
  - ***Sample Repository.*** Thrust Area 6 narratives must also clearly identify how the applicant plans to maintain samples collected during the proposed research effort, along with relevant metadata, for at least 12 months after the project end date. Note that annual sample repository information must be submitted using a DTRA-specified format that is available in the Document and Template Library online at the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal)).
  - ***Protection of Human Subjects.*** For full discussion, see Section 6.2.2. If the proposed research does involve human subjects or materials, applicants are asked to: a) justify the use of human subjects, b) outline the human use, and c) include the source of the human subjects or materials involved in the research. Applicants shall submit written evidence, to include a provisional protocol number and Institutional Review Board (IRB) point of contact information, that a human use protocol has been submitted to, and is pending approval by, a qualified IRB. Further information may be required if the proposal is successful.
  - ***Animal Use.*** For full discussion, see Section 6.2.3. If the proposed research involves animal use, applicants are asked to justify the use of animals. Any proposals involving animal studies or animal work must include detailed information on the animal protocols to be used and verify the location where the studies will be conducted. Animal studies are subject to review and approval for safety and adherence to regulations. Applicants shall submit with the full proposal package written evidence, to include a provisional protocol number and Institutional Animal Care and Use Committee (IACUC) point of contact information, that a vertebrate animal use protocol has been submitted to, and is pending approval by, a qualified IACUC. Further information may be required if the proposal is successful.
- ***Performance Schedule.*** Provide a table of tasks and sub-tasks and the duration of performance of each in a Gantt or other suitably formatted chart.
- ***References.*** List any relevant documents referenced.

Disclosure of Lobbying Activities (SF-LLL) Form: The Disclosure of Lobbying Activities

Standard Form-LLL, if applicable, should be completed.

Attachments Form: The attachments form should be used to include the following three items with the application:

Attachment 1 – SOW. The SOW does not have a page limit, but should be approximately 3-5 pages in length for incorporation into an award document. The SOW should not contain any proprietary data or markings. Pages should be numbered and the initial page should have a date (document date) shown under the title (the title of the SOW should match that of the proposal). The SOW must be provided in portrait layout. A template for the SOW format may be found online in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal) (MS Word format).

The proposed SOW must accurately describe the research to be performed. The proposed SOW must also contain a summary description of the technical methodology as well as the task description, but not in so much detail as to make the SOW inflexible. The SOW format/guidance is as follows:

- ***Objective:*** Brief overview of the specialty area. Describe why the research is being pursued and what knowledge is being sought.
- ***Scope:*** Include a statement of what the SOW covers including the research area to be investigated, objectives/goals, and major milestones and schedule for the effort.
- ***Background:*** The applicant must identify appropriate documents, including publications that are applicable to the research to be performed. This section includes any information, explanations, or constraints that are necessary in order to understand the hypothesis and scientific impact on capabilities needed to reduce, eliminate, and counter the threat, and also mitigate the effects of WMD. It may also include previously performed relevant research and preliminary data.
- ***Tasks/Scientific Goals:*** This section contains the detailed description of tasks which represent the research to be performed that are contractually binding. Thus, this portion of the SOW should be developed in an orderly progression and presented in sufficient detail to establish the methodology and feasibility of accomplishing the overall program goals. The work effort should be segregated by performance period for all tasks to be performed and anticipated milestones realized in that year (e.g., Year 1, Year 2, etc., should be detailed separately). Identify the major tasks in separately numbered sub-paragraphs. Each major task should delineate, by subtask, the research to be performed by year and number each task using the decimal system (e.g., 4.1, 4.1.1, 4.1.1.1, 4.2, etc.). The sequence of performance of tasks and achievement of milestones must be presented by project year and task in the same sequence as in the Project Narrative/Technical Proposal. The SOW must contain every task to be accomplished to include a detailed schedule.
- The tasks must be definite, realistic, and clearly stated. Use “the awardee shall” whenever the work statement expresses a provision that is binding. Use “should” or “may” whenever it is necessary to express a declaration of purpose. Use active voice in describing work to be performed. Do not use acronyms or abbreviations without spelling out acronyms and abbreviations at the first use; place the abbreviation in parenthesis immediately following a spelled-out phrase. If presentations/meetings are identified in your schedule, include the following statement in your SOW: “Conduct presentations/meetings at times and places

specified in the grant schedule."

- ***Deliverables:*** Thrust Area 6 **requires** several additional items be included in the SOW. These items are as follows:
  - Submission of annual sample repository information using a DTRA-specified format (for the template, please see the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal)).
  - Access to all samples collected and data generated during the course of the project, up to and including at least 12 months after the project end date.

Attachment 2 – Quad Chart. The quad chart must be presented on one (1) page. The quad chart must not contain any proprietary data or markings. The quad chart must be provided in landscape layout. A template for the quad chart format may be found online in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal) (MS PowerPoint format). The inclusion of the DTRA logo is not required. The quad chart should be uploaded as "Attachment 2" of the Attachments Form.

Attachment 3 – Supporting Documentation. For Thrust Area 6 proposals ONLY. Thrust Area 6 narratives must also describe an operational framework to support the proposed work. This includes, but is not limited to the following: the extent and duration of the relationship/collaboration between the universities/institutes/entities and/or scientists. Teams with pre-existing collaborative research relationships and those which propose to establish new collaborations will be considered, provided teams can supply documentation to demonstrate that an operational framework exists to support the proposed work. Each of the following should be concatenated into a single document, in the order specified:

- Specific identification of foreign Principal Investigators (PIs) and number of/job title for other members of the foreign research team.
- Detailed description of the relationship between the proposed research project and current research efforts at the foreign institution.
- Description of facilities and any other evidence of suitability of foreign collaborators and sites. In the event that the foreign research component will involve human or other vertebrate animal use, appropriate facilities compliance and certifications documents must be provided. Refer to Section 6.2.2 and Section 6.2.3 for specific information on required approvals and documentation.
- Foreign PI letter of collaboration describing, at minimum, the suitability of the proposed work with respect to ongoing research efforts at the foreign institution, merit of the proposed collaboration, and the expected mutual benefits.

Protocol Risk Assessment Tool (PRAT). For Thrust Area 6 proposals ONLY. Applicants **must** download the PRAT from the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal) and complete it in its entirety for **each** foreign institution participating in the project. Additional instructions for completing the PRAT may be found within the file. The completed PRAT file(s) should be emailed as a Portable Document File (PDF) format to HDTRA1-FRCWMD-A@mail.mil within two (2) weeks of the full proposal submission. **DO NOT** attempt to attach the PRAT(s) to the

www.grants.gov submission.

4.2.7. Phase II - Additional Information Requests by DTRA. A revised proposal may be requested based on the review of the original proposal. Revised proposals will be requested when changes to the project scope, technical approach, and/or cost are required before the proposal could be further considered for an award. Applicants whose proposals are of interest to DTRA may be contacted to provide additional information or to make requested revisions prior to the final decision on funding. This request for further information may include revised budgets or budget explanations, revised SOWs, and other information, as applicable, to the proposed award. Applicants who are not responsive to Government requests for information in a timely manner, defined as meeting Government deadlines established and communicated with the request and not making satisfactory updates as requested, may be removed from award consideration. Applicants may also be removed from award consideration if the applicant and the Government fail to negotiate mutually agreeable terms within a reasonable period of time.

Re-submissions should be made with the appropriate Phase II application package for the thrust area or topic of interest and should be completed in accordance with the instructions provided in the notification email.

The DTRA-specific instructions for completing a proposal re-submission are the same as for the original submission, except the SF 424 (R&R) Application for Federal Assistance should be marked as follows:

- Block 1 – Type of Submission. Applicants should indicate the Phase II submission is a "Changed/Corrected Application."
- Block 4b – Agency Routing Identifier. Enter the corresponding Phase I Grant ID.
- Block 4c – Previous Grants.gov Tracking ID. Enter the Phase II Grant ID for the original Phase II submission.

4.2.8. File Format.

Documents should be uploaded as a Portable Document File (PDF) format. Perform a virus check before uploading any files to www.grants.gov as part of your application package. If a virus is detected, it may cause rejection of the file.

Do not lock or encrypt any files you upload to www.grants.gov as part of your application package. Movie and sound file attachments will not be accepted.

4.2.9. All submissions must be completely UNRESTRICTED and UNCLASSIFIED; submissions must not contain For Official Use Only (FOUO) or Official Use Only (OUO) information or be marked as such.

4.2.10. Confirmed Proposal Expiration Date. Applicants requesting contracts must provide written confirmation that holds the proposal, to include proposed costs, firm for 180 days after the submission due date, as included in the invitation to submit a full proposal. This information must be included in the text of the technical proposal.

4.2.11. Withdrawal of Proposals. Proposals may be withdrawn by written notice received at any time before award. Withdrawals are effective upon receipt of notice by the Grants/Contracting

Officer via the administrative e-mail address listed in Section 7.

4.3. Submission Dates and Times.

Coordination of abstracts may be accomplished at any time that this BAA is in effect, unless otherwise stated as part of a specific topic. Once an applicant has been notified that a pre-application white paper is welcomed, the white paper should be submitted within 60 days. If the white paper is not submitted within 60 days, DTRA reserves the right to require the applicant to re-initiate the process with another abstract coordination.

Pre-application white papers may be submitted anytime that this BAA is in effect (as long as it occurs within the 60 day window following pre-coordination of the abstract), unless otherwise stated as part of a specific topic. Pre-application white papers may be evaluated at any time after submission and invitations for full proposal submission may occur any time after pre-application white paper evaluation. Note that proposal invitations may be limited to available program funds.

The due date for the Phase II invited proposal submissions will be provided in the letter of invitation. The applicant will not be allowed less than 45 days to prepare a full proposal submission; there is no penalty for early submissions. An extension for submission of the Phase II proposal submission may be requested by emailing the administrative email address in Section 7 prior to the deadline for the proposal submission. Full proposals may be evaluated at any time after submission.

Applicants are responsible for submitting all materials to www.grants.gov. When sending electronic files, the applicant should allow for potential delays in file transfer from the originator's computer server to the www.grants.gov website/computer server, as well as the delay associated with the www.grants.gov validation of applications, which may be up to 48 hours. Applicants are encouraged to submit their proposals early to avoid issues with file transfers, rejection of applications by www.grants.gov, and delays due to high website demand.

Acceptable evidence to establish the time of receipt at the Government office includes documentary and electronic evidence of receipt maintained by DTRA. Applicants should also print, and maintain for their records, the electronic receipt following submission of a proposal to www.grants.gov.

Applicants should note that DTRA uses a system that pulls applications from www.grants.gov en masse, but this system does not mark applications as "retrieved" on www.grants.gov. As a result, when applicants check the status on www.grants.gov the applications will always look like they have not been retrieved by DTRA. Should you require confirmation of receipt by the Agency, you may request such via the administrative email address provided in Section 7. Note that such requests will generally be treated with low priority by the Agency.

Please note 15 U.S.C. 260a establishes daylight saving time as the standard time during the daylight saving period.

If the application package and required attachments are submitted to www.grants.gov after the exact time and date specified in this announcement or in any written communications provided by DTRA, the application may be considered "late" and may not be reviewed.

If an emergency or unanticipated event interrupts normal Government processes so that proposals cannot be submitted to www.grants.gov by the exact time specified by DTRA

correspondence, the time specified for receipt of applications will be deemed to be extended to the same time of day specified in the BAA or in the letter of invitation on the first work day on which normal Government processes resume.

4.4. Intergovernmental Review. Not Applicable.

4.5. Other Submission Requirements.

4.5.1. Registration with www.grants.gov. Applicants should note that each organization must complete a one-time registration in order to submit its pre-application white paper(s) and full proposal(s) through www.grants.gov. Please see the following web link on information about registering with www.grants.gov: http://www07.grants.gov/applicants/applicants.jsp. If your organization is already registered in www.grants.gov, no further action should be required.

The registration process may take up to **four (4) weeks** to complete depending on your organization and requires multiple steps, some of which are detailed below.

- Identifying the Data Universal Number Systems (DUNS) number or registering for one with Dun & Bradstreet at http://fedgov.dnb.com/webform/displayHomePage.do if your organization does not have a DUNS number.
- Registering with the System for Award Management (SAM) by calling the SAM Assistance Center at 1-866-606-8220, or you may register online at www.sam.gov. You will NOT be able to complete your SAM registration until SAM has confirmed your Employer Identification Number (EIN) or Taxpayer Identification Number (TIN) with the Internal Revenue Service (IRS).

4.5.2. Compliance with Appendix A to 32 CFR 28. All awards require certifications of compliance with Appendix A to 32 CFR 28 regarding lobbying. The full text of this certification is available in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal). Proposers are certifying compliance with this regulation by submitting the invited proposal. It is not necessary to include the certification text with your invited proposal. If applicable, proposers should submit the Disclosure of Lobbying Activities (SF-LLL) Form in accordance with Section 4.2.6.

4.5.3. Marking Guidance for Pre-Application White Paper and Invited Proposal and Disclosure of Proprietary Information other than to the Government. The pre-application white papers and invited proposals submitted in response to this BAA may contain technical and other data that the applicant does not want disclosed to the public or used by the Government for any purpose other than application evaluation. Public release of information in any pre-application white paper and invited proposal submitted will be subject to existing statutory and regulatory requirements.

If proprietary information which constitutes a trade secret, proprietary commercial or financial information, confidential personal information, or data affecting national security, is provided by an applicant in a pre-application white paper and/or invited proposal, it will be treated in confidence, to the extent permitted by law, provided that the following legend is included on the front page of the pre-application white paper and/or invited proposal:

“For any purpose other than to evaluate the pre-application white paper and/or proposal, this data shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part, provided that if an award is made to the applicant as a result of or in connection

with the submission of this data, the Government shall have the right to duplicate, use or disclose the data to the extent provided in the agreement. This restriction does not limit the right of the Government to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained in page(s) _____ of this pre-application white paper and/or proposal."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the pre-application white paper and/or invited proposal from further consideration without assuming any liability for inadvertent disclosure.

The Government will limit dissemination of properly marked information to within official channels. In addition, the pages indicated as restricted must be marked with the following legend:

> *"Use or disclosure of the pre-application white paper and/or proposal data on lines specifically identified by asterisk (*) are subject to the restriction on the front page of this pre-application white paper and/or proposal."*

The Government assumes no liability for disclosure or use of unmarked data and may use or disclose such data for any purpose.

In the event that properly marked data contained in a pre-application white paper and/or invited proposal submitted in response to this BAA is requested pursuant to the Freedom of Information Act (FOIA), 5 U.S.C. § 552, the applicant will be advised of such request and prior to such release of information, will be requested to expeditiously submit to DTRA a detailed listing of all information in the pre-application white paper and/or invited proposal which the applicant believes to be exempt from disclosure under the Act. Such action and cooperation on the part of the applicant will ensure that any information released by DTRA pursuant to the Act is properly identified.

By submission of a pre-application white paper and/or invited proposal, the applicant understands that proprietary information may be disclosed outside the Government for the sole purpose of technical evaluation. DTRA will obtain a non-disclosure agreement from the evaluator that proprietary information in the pre-application white paper and/or invited proposal will only be used for evaluation purposes and will not be further disclosed or utilized.

4.6. Applicants that Propose Use of Contracts or OTAs.

4.6.1. Recommended Procurement Instrument and Pricing Arrangement. Applicants that propose use of contracts or OTAs must provide a summary of their recommended procurement instrument and pricing arrangement as part of the Phase II proposal. However, the Government reserves the right to negotiate and award the types of instruments determined most appropriate under the circumstances. It is anticipated that most instruments will be grants.

4.6.2. Representations and Certifications. Representations and Certifications must be completed at the time of Phase II submission. The applicant must complete the annual representations and certifications electronically via the System for Award Management (SAM) website at https://www.sam.gov/portal/SAM/#1#1. After reviewing their information, the applicant verifies by submission of the application that the representations and certifications currently posted electronically have been entered or updated within the last 12 months.

4.6.3. Organization Conflict of Interest Advisory. Certain post-employment restrictions on

former federal officers and employees may exist, including special Government employees (including but not limited to 18 U.S.C § 207, the Procurement Integrity Act, 41 U.S.C. § 2101 *et.seq*). If a prospective applicant believes that a conflict of interest exists, the situation should be raised to the DTRA Contract/Grant Officer before time and effort are expended in preparing a proposal. All applicants and proposed sub-contractors must therefore affirmatively state whether they are providing scientific, engineering and technical assistance (SETA), advisory and assistance services (A&AS) or similar support, through an active contract or subcontract, to any DoD technical office to include, but not limited to, the Joint Program Executive Office (JPEO), the Office of the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs (ASD-NCB), or the Office of the Special Assistant for Chemical and Biological Defense and Chemical Demilitarization Programs (OSA (CBD&CDP)). This information must be included in Technical Proposal of the Phase II full submission. All affirmations must state which office(s) the applicant(s) supports, and identify the prime contract number. Affirmations must be furnished at the time of Phase II full proposal submission. All facts relevant to the existence or potential existence of organizational conflicts of interest, including but not limited to those arising out of activities with the above-referenced organizations, must be disclosed. The disclosure must include a description of the action the applicant has taken or proposes to take to avoid, neutralize, or mitigate such conflict.

4.6.4. Contracts with Subcontracts. Any applicant, other than small businesses, submitting a proposal that exceeds $650,000.00 must submit a subcontracting plan in accordance with FAR 19.704(a) (1) and (2). This information must be included in Technical Proposal of the Phase II full submission. The plan format is outlined in FAR 19.704. Pursuant to Section 8(d) of the Small Business Act (15 U.S.C. § 637(d)), it is the policy of the Government to enable small business and small disadvantaged business concerns to be considered fairly as subcontractors to contractors performing work or rendering services as prime contractors or subcontractors under Government contracts, and to assure that prime contractors and subcontractors carry out this policy.

4.6.5. Limitations on OTAs. Applicants are advised that an Other Transaction for Research Agreement (10 U.S. Code § 2371) or an Other Transaction for Prototype Agreement (10 U.S. Code § 2371b) will only be awarded if the use of a standard contract or CA is not feasible or appropriate. Applicants are advised that an OTA may only be awarded if there is:

a. At least one nontraditional defense contractor participating to a significant extent in the prototype project, or

b. All significant participants in the transaction other than the Federal Government are small businesses or nontraditional defense contractors; or

c. At least one-third of the total cost of the prototype project is to be paid out of funds provided by the parties to the transaction other than the Federal Government. The cost share should generally consist of labor, materials, equipment, and facilities costs (including allocable indirect costs).

d. Exceptional circumstances justify the use of a transaction that provides for innovative business arrangements or structures that would not be feasible or appropriate under a procurement contract.

e. Although use of one of these options is required to use an Other Transaction for

Prototype agreement as the procurement vehicle, no single option is encouraged or desired over the others.

NOTE: For purposes of determining whether or not a participant may be classified as a nontraditional defense contractor or a small business and whether or not such participation is determined to be participating to a significant extent in the prototype project, the following definitions are applicable:

a. "Nontraditional defense contractor" means an entity that is not currently performing or has not performed, for at least the one-year period preceding this solicitation, any of the following for the Department of Defense: any contract or subcontract that is subject to full coverage under the cost accounting standards prescribed pursuant to section 26 of the Office of Federal Procurement Policy Act (41 USCS §§ 1501 et seq.) and the regulations implementing such section; or any other contract in excess of $500,000 under which the contractor is required to submit certified cost or pricing data under section 2306a of this title (10 USCS § 2306a).b. "Small business" means a small business concern as defined under Section 3 of the Small Business Act (15 U.S.C. § 632).

"Participating to a significant extent in the prototype project" means that the nontraditional defense contractor or small business is supplying a new key technology or product, is accomplishing a significant amount of the effort wherein the role played is more than a nominal or token role in the research effort, or in some other way plays a significant part in causing a material reduction in the cost or schedule of the effort or an increase in performance of the prototype in question. NOTE: Applicants are cautioned that if they are classified as a traditional defense contractor, and propose the use of an Other Transaction for Prototype Agreement, the Government will require submittal of both a cost proposal under the guidelines of the FAR/DFARS, and a cost proposal under the proposed Other Transaction for Prototype Agreement, so that an evaluation may be made with respect to the cost tradeoffs applicable under both situations. The Government reserves the right to negotiate either a FAR based procurement contract, or Other Transaction for Prototype Agreement as it deems is warranted under the circumstances.

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5. APPLICATION REVIEW INFORMATION

5.1. Evaluation Criteria. The four evaluation criteria to be used for responses received to this BAA are as follows:

1. Scientific and Technical Merit. The objective of this criterion is to assess the extent to which the applicant presents ideas that are innovative and/or unique with the potential for high payoff in the science area and details a comprehensive technical approach based on sound scientific principles. Innovation will be judged contextually against the white paper's/proposal's scope, goals, and setting. To the extent possible, the technical risks, including those of biosafety and security, to accomplish the research or project should be identified with appropriate mitigation/management details.

   For Thrust Area 6 white papers/proposals, innovation will also be considered with respect to

partner country capabilities.

2. Value to Mission Goals. The objective of this criterion is to assess the extent to which the applicant demonstrates an understanding of the C-WMD research or mission challenges and the contribution to the C-WMD research or mission needs of that thrust area/topic. White papers/proposals must detail research or a project that is responsive to the thrust area/topic as presented in this solicitation. This criterion also addresses the benefit of the proposed effort on enabling knowledge, technology, or capabilities over current methods and/or practices and on the transition potential that is appropriate to the proposed effort. Applicants must also demonstrate an impact of the proposed effort on the institution's ability to perform research relevant to reducing the global WMD threat; and/or to train, through the proposed effort, students and/or partner scientists in science, technology, engineering and/or mathematics.

   Thrust Area 6 white papers/proposals must demonstrate an understanding of the CBEP priorities and mission. As such, the degree to which the proposed collaborations may lead to long-term partner country self-sufficiency and sustainment of the jointly developed capabilities will be considered.

3. Capability of the Personnel and Facilities to Perform the Proposed Effort. The objective of this criterion is to assess the extent to which the applicant's team has the requisite expertise, skills and resources necessary to perform the proposed program. This includes an assessment of the team's management construct, key personnel, facilities and past technical experience in conducting similar efforts of the proposed scope. Applicants must demonstrate that their team has the necessary background and experience to perform this project. Facilities should be detailed with discussion of any unique capabilities pertinent to the research. Subcontractors may include Government facilities or Agencies; however the unique expertise or specialized facilities provided through their inclusion must be clearly presented and the validity of the proposer-Governmental relationship must be clearly documented.

4. Cost Realism Evaluation. The objective of this criterion is to establish that the proposed costs are reasonable, realistic, and justified for the technical approach offered and to assess the applicant's practical understanding of the scope of the proposed effort.

5.2. Review and Selection Process.

The pre-application white paper and proposal selection process will be conducted based upon a technical review as described in the DoDGARs (32 CFR 22.315(c)) and includes the use of non-Government peer-reviewers.

Each pre-application white paper and invited proposal submitted to a general TA will be reviewed on a rolling basis; topic-based submissions will be reviewed as a batch following receipt deadlines. All applications will be reviewed based on the merit and relevance of the specific pre-application white paper/proposal as it relates to the DTRA program, rather than against other pre-application white papers/proposals for research in the same general area.

Pre-application white paper (Phase I) evaluation will be based on the two (2) equally weighted criteria of (1) Technical/Scientific Merit and (2) Value to Mission Goals. The criteria will be scored as Outstanding (O), Good (G), Acceptable (A), Marginal (M) or Unacceptable (U). Any criterion scored as "Unacceptable (U)" will render the pre-application white paper "Not Selectable," and the pre-application white paper will not be considered further.

The full proposal evaluation will be based on the four criteria listed above. Of these, the first

two (2) criteria of (1) Technical/Scientific Merit and (2) Value to Mission Goals are equally weighted and more important than the third criterion of (3) Capability of the Personnel and Facilities to Perform the Proposed Effort. These first three criteria will be scored Outstanding (O), Good (G), Acceptable (A), Marginal (M) or Unacceptable (U). The fourth criterion of Cost Realism will be scored as either Acceptable (A) or Unacceptable (U). Any criterion scored as "Unacceptable (U)" will render the proposal "Not Selectable," and the proposal will not be considered further.

Other factors that may be considered are duplication with other research, program balance, past performance and budget limitations. Prior to award, the Government reserves the right to perform a review of past performance. Sources that may be used for past performance review may include the Past Performance Information Retrieval System (PPIRS) and the Federal Awardee Performance and Integrity Information System (FAPIIS). The Government will also evaluate the impact of any proposed limitations to the use of intellectual property (e.g. asserted technical data/computer software restrictions or patents) during the selection and/or negotiation process, and may request additional information from the applicant, as may be necessary, to evaluate the applicant's assertions. Accordingly, proposals may be selected for funding which are not reviewed as highly as others, which are of higher risk and/or which may be of a higher cost.

The Government reserves the right to select all, some, or none of the proposals, or any part of any proposal received in response to this BAA and to make awards without discussions with applicants; however, the Government reserves the right to conduct discussions if determined necessary.

5.3. DTRA anticipates that the total Federal share of awards made under this announcement will be greater than the simplified acquisition threshold over the period of performance (see §200.88 Simplified Acquisition Threshold). Therefore, in accordance with Appendix I to 2 CFR Part 200, Section E.3, this section serves to inform applicant:

i. That DTRA, prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold, is required to review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM (currently Federal Awardee Performance and Integrity Information System (FAPIIS)) (see 41 U.S.C. 2313);

ii. That an applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM and comment on any information about itself that a Federal awarding agency previously entered and is currently in the designated integrity and performance system accessible through SAM;

iii. That DTRA will consider any comments by the applicant, in addition to the other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in §200.205 Federal awarding agency review of risk posed by applicants.

iv. For awards that exceed $500,000 over the period of performance, DTRA will employ the additional post-award reporting requirements reflected in Appendix XII—Award Term and Condition for Recipient Integrity and Performance Matters of 2 CFR 200.

5.4. Technical and Administrative Support by Non-Government Personnel.

It is the intent of DTRA to use both Government and non-Government personnel to assist with the review and administration of submittals for this BAA. All pre-application white papers and invited proposals may be reviewed by subject matter experts, including, but not limited to, peer reviewers from across the academic and industrial community, as applicable to the research proposed.

Further, participation in this BAA requires DTRA support contractors to have access to pre-application white paper and invited proposal information including information that may be considered proprietary or otherwise marked with restrictive legends. Existing DTRA contractors include but may not be limited to the following: Engility Corporation (Advisory & Assistance Services) and their subcontractors, Infinity Technology LLC, Quanterion Solutions Inc., Kforce Government Solutions Inc., KCK Inc., CACI,, , SBG Technology Solutions and their subcontractors, and Terremark Worldwide Inc. Each contract contains organizational conflict of interest provisions and/or includes contractual requirements for non-disclosure of proprietary contractor information or data/software marked with restrictive legends. The Offeror, by submitting a white paper or proposal, is deemed to have consented to the disclosure of its information to the aforementioned contractors under the conditions and limitations described herein.

All individuals—including subject matter experts and support contractors—having access to any proprietary data must certify that they will not disclose any information pertaining to this BAA including any submittal, the identity of any submitters, or any other information relevant to this BAA. All applicants to this BAA consent to the disclosure of their information under these conditions.

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6. AWARD ADMINISTRATION INFORMATION

6.1. Award Notices. Applicants will be notified regarding the status of their applications (invitation/non-invitation for full proposals, re-submission of white papers, selection/non-selection for award, etc.) via e-mail to the BPOC listed in Block 5 of the SF-424 and the PI listed in Block 14 of the SF-424 provided at the time of submission. A debrief summary will be provided as part of all notification e-mails.

A notice of selection should not be construed as an obligation on the part of the Government; only duly authorized procurement personnel may commit resources, this will be done by issuing a grant or contract document to the selected applicant. Also, this notification must not be used as a basis for accruing costs to the Government prior to award. Selected applicants are not authorized to begin work, as any award is subject to successful negotiations (if determined necessary by DTRA) between the DTRA contracting division and the selected organization, and to the availability of funds.

All notifications will be made from notification@dtrasubmission.net. **E-mails to this e-mail address will not be answered or forwarded.**

Applicants must be aware that it is their responsibility to ensure: (1) correct e-mail addresses are provided at the time of submission, (2) this e-mail notification reaches the intended recipient(s), and (3) the e-mail is not blocked by the use of ‘spam blocker’ software or other means that the

recipient's Internet Service Provider may have implemented as a means to block the receipt of certain e-mail messages.

If for any reason there is a delivery failure of these e-mail notices, DTRA will not further attempt to contact the applicants.

6.2. Administrative and National Policy Requirements. The DTRA Grant Terms and Conditions may be found online in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal). There are different versions for different recipients. As the Terms and Conditions are updated, they will be posted in the Document & Template Library of the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal). All awards require certifications of compliance with national policy requirements. Statutes and Government-wide regulations require some certifications to be submitted at the time of proposal submission. See Section 4.5.2 and Section 4.6.2 for the certification(s) required at the time of submission.

This BAA focuses on fundamental research in a DoD contractual context, which was defined in Section 1.2 of this BAA. Per DoD policy[1], "…products of fundamental research are to remain unrestricted to the maximum extent possible." Furthermore, "The DoD will place no other restrictions on the conduct or reporting of unclassified fundamental research, except as otherwise required by statue [sic], regulation, or Executive Order." As such, fundamental research is normally exempt from controls under the International Traffic in Arms Regulation (ITAR) (22 CFR Parts 120-130) and/or the Department of Commerce regarding the Export Administration Regulations (15 CFR Parts 730-774), but the DoD rule recognizes that there are "rare" situations where export-controlled information or technology may be used in fundamental research that may require a license(s) or restrictions on products.

6.2.1. Export Control Notification. Applicants are responsible for ensuring compliance with any export control laws and regulations that may be applicable to the export of and foreign access to their proposed research. Applicants may consult with the Department of State with any questions regarding the International Traffic in Arms Regulation (ITAR) (22 CFR Parts 120-130) and/or the Department of Commerce regarding the Export Administration Regulations (15 CFR Parts 730-774). Please note that the prime awardee is responsible for monitoring ITAR compliance of all subawardees.

6.2.2. Protection of Human Subjects. If the proposed research involves human subjects or materials, applicants are asked to: a) justify the use of human subjects, b) outline the human use, and c) include the source of the human subjects or materials involved in the research. As a condition precedent to receipt of DTRA funding, applicants must ensure that the basic rights and welfare of human subjects are protected. Applicants shall submit with the full proposal package written evidence, to include a provisional protocol number and Institutional Review Board (IRB) point of contact information, that a human use protocol has been submitted to, and is pending approval by, a qualified IRB. Further information may be required if the proposal is successful.

All research under any award made under this BAA involving human subjects must be conducted in accordance with 32 CFR 219, 10 U.S.C. § 980, and DoD Instruction 3216.02, and,

[1] Under Secretary of Defense for Acquisition, Technology and Logistics Memorandum, SUBJECT: Contracted Fundamental Research, dated 26 Jun 2008

as applicable, 21 CFR parts 11, 50, 56, Good Clinical Practice, the ICH, as well as other applicable federal and state regulations. Awardees must be cognizant of and abide by the additional restrictions and limitations imposed on the DoD regarding research involving human subjects, specifically as regards vulnerable populations (32 CFR 219 modifications to subparts B-D of 45 CFR 46), recruitment of military research subjects (32 CFR 219), and surrogate consent (10 U.S.C. § 980).

DTRA Directive 3216.01 of June 9, 2010, modified March 18, 2015, established the DTRA Human Subjects Protection Program, set forth the policies, defined the applicable terms, and delineated the procedures necessary to ensure DTRA compliance with federal and DoD regulations and legislation governing human subject research. The regulations mandate that all DoD activities, components, and agencies protect the rights and welfare of human subjects of study in DoD supported research, development, test and evaluation, and related activities hereafter referred to as "research." The requirement to comply with the regulations applies to new starts and to continuing research.

The DTRA Directive requires that research using human subjects may not begin or continue until the DTRA Research Oversight Board (ROB) has reviewed and approved the proposed protocol. Contractors and subcontractors are required to submit a valid federal assurance for their organization (institution, laboratory, facility) that has been issued by either DoD or the Department of Health and Human Services, and documentation of review of proposed protocols by the local IRB to include consent forms for any planned research using human subjects to the DTRA ROB for its review through the contracting officer's representative (if assigned) or the contracting officer. The ROB review is separate from, and in addition to, local IRB review.

A study is considered to involve human research subjects if: 1) there is interaction with the subject (even simply talking to the subject qualifies; no needles are required); and 2) if the study involves collection and/or analysis of personal/private information about an individual, or if material used in the study contains links to such information.

Written approval to begin research or to subcontract for the use of human subjects under the proposed protocol will be provided in writing from the DTRA ROB, through the contracting officer. Both the contractor and the Government must maintain a copy of this approval. Any proposed modifications or amendments to the approved protocol or consent forms must be submitted to the local IRB and the DTRA ROB for review and approval. Examples of modifications/amendments to the protocol include, but are not limited to:

- a change of the Principal Investigator;
- changes in duration or intensity of exposure to some stimulus or agent;
- changes in the information requested of volunteers, or changes to the use of specimens or data collected; or
- changes in perceived or measured risks or benefits to volunteers that require changes to the study.

Research pursuant to such modifications or amendments must not be initiated without IRB and ROB approval except when necessary to eliminate apparent and immediate hazards to the subject(s).

Research projects lasting more than one year require IRB review at least annually, or more

frequently as required by the responsible IRB. The contractor or subcontractor must provide documentation of continued IRB review of protocols for ROB review and approval in accordance with the Contract Data Requirements List. Research changes must be reviewed by the IRB and ROB in advance unless necessary to eliminate apparent and immediate hazards to the subject(s).

A clause regarding human subjects research will be included in all contracts involving human subjects research. Non-compliance with any provision of this clause may result in withholding of payments under the contract pursuant to the contract's payments clause(s) and/or contract termination pursuant to the contract's termination clause(s). The Government shall not be responsible for any costs incurred for research involving human subjects prior to protocol approval by the ROB.

6.2.3. Animal Use. If the proposed research involves the use of live nonhuman vertebrate animals, applicants are required to justify the use of animals by providing detailed information on the proposed animal use, to include the proposed species and number of animals planned, along with the location(s) where the animal study(ies) is planned. Additional information will be required if the proposal is selected for award subject to successful negotiations. The Animal Care and Use Review Office (ACURO), a component of the USAMRMC Office of Research Protections (ORP), must review and approve all animal use prior to the start of working with animals. Therefore, Principle Investigators will be required to complete and submit the animal use appendix titled "Research Involving Animals", after award of the procurement instrument, which is available on the ACURO website (http://mrmc.amedd.army.mil/index.cfm?pageid=research_protections.acuro). Allow 2 to 4 months for regulatory review and approval processes for animal studies. Applicants are to build this review time into their project schedules.

DoD Instruction 3216.01, dated September 13, 2010, provides policy and requirements for the use of animals in DoD-funded research based on Army Regulation (AR) 40-33. The DoD definition of animal is any live nonhuman vertebrate. All proposals that involve the use of animals must be in compliance with DoD Instruction 3216.01 and AR 40-33. DTRA requires that research using animals not begin or continue until the ACURO has reviewed and approved the proposed animal use. For animals, the provisions include rules on animal acquisition, transport, care, handling, and use in: (i) 9 CFR parts 1-4, Department of Agriculture rules that implement the Laboratory Animal Welfare Action of 1966 (U.S.C. 2131-2156); and (ii) the "Guide for the Care and Use of Laboratory Animals," National Institutes of Health Publication No. 86-23.

6.2.4. Biological Defense Research Program (BDRP) Requirements: BioSurety and Select Agent Use.

Proposals must specify what Select Agent work will be conducted at the applicant's facility and what Select Agent work will be performed in other facilities. Proposals also must provide the source of the Select Agent(s), any appropriate registration information for the facilities, and specify the Laboratory Bio-safety Level. All Select Agent work is subject to verification of information and certifications. Further information may be required if the proposal is successful.

For those institutions in which PI's are conducting research with Bio-safety Levels 3 and 4 material, a Facility Safety Plan must be prepared and made available during the project award phase in accordance with 32 CFR 626.18. For grants awarded to foreign institutions, you must

follow either local or U.S. laws (as stated above) depending on which laws provide stronger protection. (DTRA requires that research using Select Agents not begin or continue until DTRA has reviewed and approved the proposed agent use. See URL: https://www.gpo.gov/fdsys/pkg/CFR-2002-title32-vol3/pdf/CFR-2002-title32-vol3-sec626-18.pdf for a copy of 32 CFR 626.18, Biological Defense Safety Program.)

For projects that will employ the use of chemical agents, either neat agent or dilute agent, the offeror must provide approved Facility Standard Operating Procedures that conform to Federal, State and local regulations and address the storage, use and disposition of these chemical materials.

6.2.5. Dual-Use Potential. In accordance with National Science Advisory Board for Biosecurity (NSABB) recommendations, DTRA will not support research that, based on current understanding, can reasonably be anticipated to provide knowledge, information, products, or technologies that could be directly misapplied to pose a significant threat with broad potential consequences to public health and safety, agricultural crops and other plants, animals, the environment, materiel, or national security. Research involving select agents and toxins is within scope of the DTRA mission; however, the use of select agents and toxins in certain experimental categories is considered "dual-use research of concern" (DURC) according to U.S. policy. (http://www.phe.gov/s3/dualuse/Documents/us-policy-durc-032812.pdf) Proposals that contain DURC will not be funded. Dual-use potential will be assessed based on application of the following criteria:

- Use of select agents or toxins. This factor evaluates whether the proposed research involves use of one or more select agents or toxins [as identified by the Select Agent Program under Federal Law (7 C.F.R. part 331, 9 C.F.R. part 121, and 42 C.F.R. part 73)] which pose significant risk of deliberate misuse with potential for mass casualties or devastating effects to the economy, critical infrastructure, or public confidence.
- Scope of proposed experiments. This factor evaluates whether the proposed research involves experiments that will produce, aim to produce, or is reasonably anticipated to produce: (a) Enhanced harmful consequences of the agent or toxin; (b) Disruption of immunity or effectiveness of an immunization against the agent or toxin without clinical or agricultural justification; (c) Conferred resistance by the agent or toxin to clinically or agriculturally useful prophylactic or therapeutic interventions against the agent or toxin, or facilitated ability to evade detection methodologies; (d) Increased stability, transmissibility, or dissemination ability of the agent or toxin; (e) Altered host range or tropism of the agent or toxin; (f) Enhanced susceptibility of a host population to the agent or toxin; or (g) Eradicated or extinct select agents or toxins.

6.2.6. Military Recruiting. This is to notify potential applicants that each award under this announcement to an institution of higher education, with exception of any grants awarded to institutions of higher education entirely located outside the United States and/or its territories, must include the following term and condition: "As a condition for receipt of funds available to DoD under this award, the recipient agrees that it is not an institution of higher education (as defined in 32 CFR 216) that has a policy of denying, and that it is not an institution of higher education that effectively prevents, the Secretary of Defense from obtaining the following for military recruiting purposes: (A) entry to campuses or access to students on campuses; or (B) access to directory information pertaining to students. If the recipient is determined, using

procedures in 32 CFR 216 to be such an institution of higher education during the period of performance of this agreement, and therefore to be in breach of this clause, the Government will cease all payments of DoD funds under this agreement and all other DoD grants and CAs, and it may suspend or terminate such grants and agreements unilaterally for material failure to comply with the terms and conditions of award." 32 CFR 216 may be accessed electronically at http://www.ecfr.gov/cgi-bin/text-idx?SID=ee45add5e352854b7089ce420c7fd0a6&mc=true&tpl=/ecfrbrowse/Title32/32cfr216_main_02.tpl . If your institution has been identified under the procedures established by the Secretary of Defense to implement Section 558 of Public Law 103-337, then: (1) no funds available to DoD may be provided to your institution through any grant, including any existing grant; and (2) your institution is not eligible to receive a grant in response to this BAA. This is to notify potential applicants that each award under this announcement to an institution of higher education, with exception of any grants awarded to institutions of higher education entirely located outside the United States and/or its territories, must include the following clause: 32 CFR 22.520 (DoDGARS 22.520), Military Recruiting and Reserve Officer Training Corps Program Access to Institutions of Higher Education.

6.2.7. Combating Trafficking in Persons. The recipient agrees to comply with the trafficking in persons requirement in Section 106(g) of the Trafficking Victims Protection Act of 2000 (TVPA), as amended (22 U.S.C. 7104(g)).

6.2.8. Reporting Subawards and Executive Compensation. The recipient agrees to ensure they have the necessary processes and systems in place to comply with the reporting requirements of the Transparency Act, as defined at 2 CFR 170.320, unless they meet the exception under 2 CFR 170.110(b).

6.2.9. Representation Regarding the Prohibition on Using Funds under Grants and Cooperative Agreements with Entities that Require Certain Internal Confidentiality Agreements. By submission of its proposal or application, the applicant represents that it does not require any of its employees, contractors, or subrecipients seeking to report fraud, waste, or abuse to sign or comply with internal confidentiality agreements or statements prohibiting or otherwise restricting those employees, contractors, or subrecipients from lawfully reporting that waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information. Note that: (1) the basis for this representation is a prohibition in section 743 of the Financial Services and General Government Appropriations Act, 2015 (Division E of the Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. 113-235) and any successor provision of law on making funds available through grants and cooperative agreements to entities with certain internal confidentiality agreements or statements; and (2) section 743 states that it does not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

6.3. Reporting. General requirements are provided below; however, each awardee should check the award agreement and its contract data requirements list (CDRLs) and/or terms and conditions to determine the requirements for that specific award.

6.3.1. Annual Reports. Annual Reports will be due no later than 1 July of each year. Awards effective after 31 January will not require an Annual Report until 1 July of the following year.

The Annual Report is *not* a cumulative report.

6.3.2. Final Technical Reports. A comprehensive final technical report is required prior to the end of an effort, due on the date specified in CDRLs and/or the terms and conditions of the award document. The purpose of the Final Report is to document the results of the effort. The Final Report *is* a cumulative report.

The final report will always be sent to the Defense Technical Information Center (DTIC) and reports may be available to the public through the National Technical Information Service (NTIS).

6.3.3. Financial Reports. Federal Financial Reports (SF-425) are due no later than 1 July of each year. Grants effective after 31 January will not require a Federal Financial Report until 1 July of the following year.

6.3.4. Foreign Travel Reports. Within thirty (30) days after returning to the United States from foreign travel, the PI may be required to submit an acceptable trip report summarizing the highlights of the trip. For grants, contracts, or OTAs awarded to institutions entirely located outside the United States and/or its territories, this is not required.

6.4. After-the-Award Requirements for *Grants*. Closeout, subsequent adjustments, continuing responsibilities, and collection of amounts due are subject to requirements found in 32 CFR 32.71 – 73 (Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations) and 32 CFR 34.61 – 63 (For-Profit Organizations).

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7. AGENCY CONTACTS

Administrative Correspondence and Questions	HDTRA1-FRCWMD-A@mail.mil
Thrust Area 1: *Science of WMD Sensing and Recognition*	HDTRA1-FRCWMD-TA1@mail.mil
Thrust Area 2: *Network Sciences*	HDTRA1-FRCWMD-TA2@mail.mil
Thrust Area 3: *Science for Protection*	HDTRA1-FRCWMD-TA3@mail.mil
Thrust Area 4: *Science to Defeat WMD*	HDTRA1-FRCWMD-TA4@mail.mil
Thrust Area 5: *Science to Secure WMD*	HDTRA1-FRCWMD-TA5@mail.mil
Thrust Area 6: *Cooperative Counter WMD Research with Global Partners*	HDTRA1-FRCWMD-TA6@mail.mil
Thrust Area 7: *Fundamental Science for Chemical and Biological Defense*	HDTRA1-FRCWMD-TA7@mail.mil

Table 6: Agency Contacts.

7.1. Questions regarding administrative content of this BAA must be addressed to the administrative e-mail address listed above.

7.2. Questions regarding technical content of this BAA must be referred to the technical staff

responsible for the relevant thrust areas.

DTRA will not release employee personal contact information.

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8. OTHER INFORMATION

Topics from previous periods may or may not be repeated. DTRA will not provide additional information regarding the posting of future topics, including dates for posting, the potential for a topic to be repeated in out years, the potential for similar topics to be posted, and/or topic details in advance of issuance of an amended BAA.

ATTACHMENT 1: SPECIFIC TOPICS

Thrust Area 6 has no specific topics at this time.

Thrust Areas 1, 2, 3, 4, 5, and 7 have specific topics—Topics H1-H16—detailed below. Submissions to the general thrust area descriptions for these thrust areas in accordance with the requirements detailed in this BAA are also welcome.

Great care must be taken to use the appropriate application package on www.grants.gov, as the package selection dictates how each submission will be reviewed:

- If NOT submitting to one of the specific topic numbers detailed below, use one of the **Thrust Area N NO TOPIC** packages
- If you ARE submitting to one of the specific topic numbers detailed below, use the applicable **Basic Research-Thrust Area N-Topic H1 to H16** package

*****BASIC RESEARCH TOPICS H1-H16*****

In accordance with Section 4.2.1, the requirement for abstract pre-coordination is waived for Topics H1-H16; these topics do NOT require pre-coordination of an abstract prior to the submission of pre-application white papers. All other pre-coordination requirements remain in effect.

The pre-application white paper deadline for Topics H1-H16 is 28 February 2018. **PRE-APPLICATION WHITE PAPERS FOR THESE TOPICS MUST BE SUBMITTED BY 11:59 PM (MIDNIGHT) EST ON 28 FEBRUARY 2018.** White papers submitted to Topics H1- H16 may not be considered if they are received after this deadline.

Responses to Topics H1-H16 must address ONLY basic research. Basic research is the systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind. It includes all scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. It is farsighted, high payoff research that provides the basis for technological programs.[2]

Topics H1-H16 are interested in research projects that span from those that focus on exploratory aspects of a unique problem or a high-risk approach to those that involve a comprehensive program with interdisciplinary areas. Consistent across all proposals should be the focus on innovative research with the potential for high impact to C-WMD science.

DTRA anticipates that the predominance of awards made under Topics H1-H16 will be grants. Pre-application white papers and proposals submitted to Topics H1-H16 must have a single lead organization and single submission for the pre-application white paper and the invited proposal. Awards will be made by a single award to the lead institution. Subawards, including all grants and/or contracts, are the responsibility of the award recipient; exceptions will not be made.

[2] DoDI 3210.1, September 16, 2005

Basic Research-Thrust Area 1-Topic H1: Predicting Trends for Combined High Stopping Power and Energy Resolution Tl-based Materials for Detecting Gamma Radiation

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: Detection of gamma rays emitted by special nuclear materials is an important problem for detecting nuclear weapons. Most existing scintillation materials for gamma-ray detection are limited in their usefulness because their properties only provide high fidelity in one detection capability, energy resolution or stopping power, at the expense of the other. Sodium Iodide activated with thallium, one of the most common materials, is widely recognized for easy utility in room temperature gamma radiation detection, but has poor energy resolution. Additional examples include bismuth germinate (BGO), with high stopping power but poor energy resolution, and lanthanum bromide ($LaBr_3$) with high energy resolution but lower stopping power.

In recent years, a new family of materials based on thallium, with its high atomic number (high effective Z) has emerged which could combine these properties. One example of these materials is Tl_2LaCl_5:Ce that shows promise to have resolution twice as good as sodium iodide. $TlMgCl_3$ is another thallium-based scintillator that has been studied with similarly good resolution. Increasing the resolution by a factor greater than two would be considered a revolutionary jump for automatic spectrum analysis techniques when detecting and discriminating among radioisotopes. It is not necessary to achieve the same level of resolution as provided by high purity germanium detectors to increase utility of scintillators in future detection applications, but to get there we must be better able to understand how to seek new scintillation candidates.

Materials that include an effective $Z \geq 65$, density ≥ 5 g/cm^3, and energy resolution better than 3.5% at 662 keV may be expected to offer the desired combination of stopping power and resolution. However, understanding the trends that lead to future successful candidates is not as obvious since the resolution, unlike the role of density and atomic number in stopping power, is not explained simply by identification of one constituent. Basic research is needed to understand

the factors that drive improvements in scintillation among thallium-based scintillators, in order to predict which material combinations may demonstrate strong combinations of stopping power and energy resolution. Thallium compounds in recent research findings drive this topic, but a scientific interest is to also answer whether this is too narrow. Of further interest is a theoretical and modelling understanding of whether or not another high-Z element other than thallium may show wide-spread promise in combined stopping power and energy resolution without too many deleterious side-effects (e.g., unstable constituents, radioactivity).

Impact: New materials capable of stopping gamma radiation efficiently will have a major effect on radiation detectors for nuclear weapons and related material. Small detectors can be facilitated by high intrinsic efficiency. Such advances also have the potential for providing cost reductions, and making the devices more ubiquitous. This is augmented by room temperature materials with high energy resolution which allow selective identification of nuclear material types.

Objective: This topic seeks basic research to understand how the presence of thallium interacts with other elements in non-elpasolite crystal compounds to lead to good scintillation properties, in addition to inherent stopping power. The goals go beyond further characterization of the existing material examples which have already been studied. The objective is to predict which thallium-based compositions produce the best combination of scintillation and material properties. Theoretical and modelling approaches are as important as experimentation to guide the prediction and potential discovery of new thallium-based scintillator materials.

Research areas may include, but are not limited to:

- Conduct modeling efforts and theoretical analyses to understand fundamental mechanisms predicting how resolution and stopping power together improve as thallium-based scintillating material compositions are varied. Examples may start with investigating the factors contributing to properties in recently discovered materials such as $TlMgCl_3$ or Tl_2LaCl_5:Ce, but need to provide predictive power beyond these examples to better understand the scintillation properties such as light yield, variation with dopants and in general reasons for the effects of modifications of composition or crystal structure.
- Conduct experimental studies to verify or disprove trends for additional new thallium-based high-Z materials. Perform a phased approach combining theory/modelling followed by experimentation. Conduct an iterative approach to help refine predictive methods and knowledge of the thallium contribution to scintillation mechanisms among compounds.
- Gain insight, from exploration of the fundamental mechanisms regarding thallium-based families, as to whether or not another high-Z element may suggest similar expected results- create or significantly advance methods to predict if there is a new high performance scintillation family waiting to be discovered.

Basic Research-Thrust Area 1-Topic H2: Prompt Signatures of Nuclear Detonations and their Interactions with Existing Urban Networks for Forensics

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: This topic explores novel methods and techniques in the measurement and analysis of the prompt signatures of nuclear explosions for forensics purposes. Ideally, this knowledge would be available in a short time with a high degree of confidence. Prompt signatures including but not limited to electromagnetic pulse, optical, gamma rays, infrasound, pressure/seismic waves and their interactions with existing networks have the potential to contribute to early-time attribution efforts [1]. The Defense Threat Reduction Agency is responsible for research and development that will enable an improvement in post-detonation technical nuclear forensics capabilities. This topic investigates basic physical research on the prompt signatures of nuclear explosive events, such as novel methods for yield determination or the radiation outputs of these nuclear explosions. These signatures are generally separate from radiochemical signatures that may require multiple days to collect and analyze. Of specific interest, is the exploration of sensing prompt signatures via their interaction with existing urban networks and their ability to contribute to device knowledge. Urban areas contain a multitude of networks that passively monitor and relay information to various sources. Prompt output from a nuclear detonation can interact with the existing networks or alter information flow that has the potential to create additional characteristic signatures. Fundamentally, the underlying interaction, subsequent emission, and propagation of measurable signatures have the potential to create additional early-time diagnostic data. The feasibility and detection limits of these signatures are also of interest. This topic is not exploring the development of stand-alone sensors for prompt signatures.

Impact: Research into the interactions of prompt signatures will enable rapid technical nuclear forensics supporting attribution. Knowing the specifics of a nuclear device (e.g., special nuclear material type) in as short a time as possible, with a high degree of confidence, is the ultimate

goal of technical nuclear forensics. Shortening the technical nuclear forensics timeline, for when knowledge becomes available, could have a revolutionary impact on technical indicators used for early-time attribution. Expanding diagnostics of prompt signatures of the nuclear event has the potential to greatly reduce the attribution timeline because of the immediate nature of these important signatures.

Objective: This topic explores novel methods and techniques in the measurement and analysis of the prompt signatures of nuclear explosions for forensics purposes. Specifically, the exploration of using an existing urban network's resultant behavior from a nuclear detonation as a sensing mechanism of a prompt signature.

Research areas may include, but are not limited to:

- Explore the interaction of prompt signatures, and investigate the potential utility of sensing prompt signatures, with the following (and other) networks:
  - Solar panel arrays distributed in urban environments
  - Cell phone towers and relay stations
  - Gunshot (or gunfire) detection systems
  - Weather observation stations
  - EPA RadNet air monitors
  - Power grid
  - Traffic and security cameras
  - Self-driving cars
  - Electric car batteries
  - State-of-health sensors for the above and other networks (e.g. natural gas networks)
  - Ubiquitous materials found in urban environments
  - Real-time passively monitored systems
- Prompt signature propagation to include:
  - Investigate absorption and attenuation of Teller light in complex environments
  - Investigation of techniques to account for scattering effects of radiation transport in urban environments
  - Investigation of optical properties of air for signal propagation, exploring reflection and attenuation coefficients as a function of air composition and frequency
  - Exploration of the use of RF bands to determine turbulence

References:

[1] R. Stone, "Surprise nuclear strike? Here's how we'll figure out who did it," Science, 11 Mar 2016, doi:10.1126/science.aaf4194

[2] www.epa.gov/radnet/learn-about-radnet

Basic Research-Thrust Area 2-Topic H3: Fundamental Quantitative Limits on Quantum Communication Networks in a Nuclear Disturbed Environment

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: In the future we expect to have a variety of quantum communications in daily use. We expect those sets of quantum communications to also be used after a nuclear event and will need to transmit through a nuclear disturbed environment. Quantum communications have unknown performance in harsh conditions such as nuclear disturbed environments that may include heat, dust, soot, turbulence, charged atmospheres, high and low altitude effects, and high EM fields. A modeling approach is sought to gain understanding of the quantitative theoretical limits [1] for quantum communications in the above mentioned environments.

Impact: The need for modeling the behavior of potential future quantum communications in a nuclear disturbed environment is important to decision makers and planners for understanding the various communications options in a nuclear disturbed environment.

Objective: The objective of this topic is to develop the mathematical body of theory to establish a quantitative limit of communication ability/transmission in a nuclear disturbed environment using quantum communications methods. Environments of interest are based upon perturbations to the atmosphere that include but are not limited to heat, dust, soot, turbulence, charged atmospheres and high EM fields. A successful proposal will include domain expertise(s) in quantum communication and the description of a nuclear disturbed environment. Teaming is encouraged. The focus is on terrestrial transmission of varying altitudes up to rarified atmospheric conditions.

Research Concentration Areas:

- Quantum communications
- Nuclear disturbed atmospheric modeling of transmission with quantum communication

systems

- Quantum entangled communications

References:

[1] Zheshen Zhang, Maria Tengner, Tian Zhong, Franco N.C. Wong, and Jeffrey H. Shapiro, Entanglement's benefit survives an entanglement-breaking channel, Phys. Rev. Lett. 111, 010501 (2013)

Basic Research-Thrust Area 2-Topic H4: Novel Approaches to Determine Missing Graph Edge and Flow Information for Physical Network Analysis

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: One of the most difficult problems in physical network analysis is the determination, given a set of assets, of the edges connecting those assets together in order to form a unique graph of vertex and edge information – thus building a network model. Likewise, a complicating factor is that in order to estimate cascading events, the initial flow between vertices/nodes along those edges must also be defined. In many real world cases those flows are not known temporally, and the connection between nodes/assets/vertices, i.e., the edges or links are also not known. This complicates the ability to make predictive models of cascading events in physical networks even if we have a well-defined set of physical governing equations (like we may have in a critical infrastructure network), and the uncertainty of those events occurring can be far beyond what is needed for disaster planning and remediation/recovery.

We seek novel approaches to determination of edge and flow data by solving the inverse problem. If we are given a limited amount of information in either the edge description or the edge flow description, we seek novel approaches to back calculate those functions, parameters or quantities from alternative information. Simple link prediction will not suffice. The inverse

solutions may not be unique, thus we also seek descriptions of the confidence of each non-unique solution if possible. We seek mathematical methodologies to extract information from observational behavior data of the physical network(s) in question to solve the inverse problem of edge and edge flow determination.

Impact: In order for planners/analysts to effectively aid decision makers concerning disaster response and planning, the behavior of critical infrastructure networks to damage must be understood. This necessitates the unique determination of the network. By having accurate networks models, predictive efforts have far lower uncertainties in many cases. This gives decision makers better understanding of the scenario and better planning capability. DTRA can help aid national decision makers and first responders with critically needed modeling capability by developing this effort.

Objective: The objective of this topic is to develop a mathematical approach to help determine edge and edge flow in a network(s) by solving the inverse problem via observational information. The relevant space of networks to be characterized could be large and diverse while the impact of disaster could evolve over many timescales of multiple orders of magnitude. Interoperation of various computational models may be a significant challenge as it is unlikely that a single model can capture an entire set of interconnected physical systems. The intent is to develop a body of theory.

Research areas may include, but are not limited to:

- Network modeling approaches for partially known and unknown networks
  - Use of synthetic data for modeling networks with limited knowledge
- Network model uncertainty control with "now-casting" of evolving systems using complex or Kalman filter-like processes with variable updating to improve edge/flow determination
- Graph theoretical methods for optimal placement of observations for solution of the inverse problem
- Graph theory, learning models, advanced link prediction and inference, critical infrastructure network response, consequence/risk assessment and management theory, deep learning, inverse problems, confidence theory, optimization, feasible set theory and other related areas are potential research concentration areas to be considered.

If a particular set of physical domain(s) is to be explored, it is important that the investigator understand the governing equations for flow associated with that physical domain. Flows can be quite complex and exhibit complex dynamics. Connectivity descriptions alone will be insufficient to describe cascading events.

Data collection is not the point of this effort. It is assumed that typical data is sufficient to demonstrate any discussed methodology or approach to the inverse problem.

Basic Research-Thrust Area 2-Topic H5: Machine Learning and Data Acquisition to Predict Human Behavior following a WMD Event

Award Amounts for this topic are anticipated to be up to $1,000,000 per year (total dollar value = direct and indirect costs). All efforts must be multidisciplinary. Preference will be given to multi-institution proposals; however, multiple PIs from a single organization are also eligible to apply. Further preference will be given to teams that have a university as the lead organization, maintain significant amounts of research at one or more universities, and include multiple opportunities for training. The proposed award value should be clearly substantiated by the scope of the effort.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: Predicting human behavior after a WMD event is important to aid in military planning for humanitarian responses when the military is called upon to assist. For WMD events there are mixed and limited data sources [1, 4, 5]. These data sources are in various forms, such as observations of social and psychological effects of people following a nuclear detonation, as well as videos and satellite imagery following the Syrian or Tokyo gas attacks. Previous work in this field has used agent based models and compartmental models to predict human behavior following a natural disaster or during an epidemic [2, 9]. These methods have been successful in estimating population movement but decline in predictive accuracy as time scales become prolonged from days to months. Additionally, these methods require educated assumptions or the use of population surveys. For example, accurately modeling human travel patterns often requires time intensive surveys of daily activities within a population. However, recent advancements in data collection and analytics have made ground truth data driven approaches more feasible due to the use of new tools like cell phones with new data types such as Global Positioning System (GPS), videos and pictures, and text. These are more abundant and available for use by researchers than ever before.

Machine learning based approaches have been successful in predicting human behavior following a variety of natural disasters [6-8]. For example, the use of deep learning coupled with heterogeneous data sources have been used to predict human behavior following a variety of natural disasters [6]. However, when modeling post-WMD events, data derived from natural disasters alone, while useful, are expected to be insufficient to accurately predict human behavior. Therefore, targeted experiments, using approaches such as virtual and augmented reality, are needed to gain additional data that can be used to train machine learning algorithims [3]. Factors that impact human behavior such as damage to the physical infrastructure (e.g. power grid, water, gas, sewage, and communications networks), government messages, and emergency response protocols should also be considered.

Impact: Accurate prediction of human behavior following a WMD event will aid in military planning for humanitarian responses when the military is called upon to provide assistance.

Objective: The research goal is to accurately predict human behavior immediately following a

WMD event to 30 days post event, using a machine learning based approach. Proposals should select two specific WMD scenarios, one must be a nuclear detonation scenario, while the other can be either a chemical, biological, or radiological scenario. Proposals should leverage past natural disaster data, conduct targeted experiments, and take into account specific factors that impact human behavior.

Examples of factors to consider may include, but are not limited to:

- Emergency response protocols.
- Location of shelters.
- Physical infrastructure damage.
- Variation within the context of traffic networks, terrain, and weather.
- Criminal activity and black market exploitation.
- Communications such as information shared with the general public, alerts, messages, the length of warning time, and the level of trust.
- Temporal effects such as the time of year.
- Demographic information such as age distribution of the impacted population.

Targeted experiments and approaches may include, but are not limited to:

- Advanced forms of data acquisition methods for incorporating real world data with synthetic examples, or use of virtual reality to provide data that is usable by machine learning algorithms.
- Utilization of machine learning approaches, including unsupervised or semi-supervised approaches, to quantitatively extract human movement from photos, satellite images, and videos.
- Methods to predict changes in human behavior resulting from damage to physical infrastructure.

References:

[1] Corbane, Christina, et al. "Monitoring the Syrian Humanitarian Crisis with the JRC's Global Human Settlement Layer and Night-Time Satellite Data." (2016).

[2] Mostafizi, Alireza, et al. "Agent-based tsunami evacuation modeling of unplanned network disruptions for evidence-driven resource allocation and retrofitting strategies." Natural Hazards (2017): 1-26.

[3] Moussaïd, Mehdi, et al. "Crowd behaviour during high-stress evacuations in an immersive virtual environment." Journal of The Royal Society Interface 13.122 (2016): 20160414.

[4] Nordlie, Peter G. An Approach to the Study of Social and Psychological Effects of Nuclear Attack. No. HSR-RR-63-3-RR. HUMAN SCIENCES RESEARCH INC MCLEAN VA, 1963.

[5] Reddy, D. S., and E. Colman. "A comparative toxidrome analysis of human organophosphate and nerve agent poisonings using social media." Clinical and

translational science 10.3 (2017): 225-230.

[6] Song, Xuan, et al. "DeepMob: Learning deep knowledge of human emergency behavior and mobility from big and heterogeneous data." ACM Transactions on Information Systems (TOIS) 35.4 (2017): 41.

[7] Song, Xuan, et al. "Intelligent System for Urban Emergency Management during Large-Scale Disaster." AAAI. 2014.

[8] Song, Xuan, et al. "Prediction and Simulation of Human Mobility Following Natural Disasters." ACM Transactions on Intelligent Systems and Technology (TIST) 8.2 (2016): 29.

[9] Verdiere, Nathalie, et al. "Mathematical modeling of human behaviors during catastrophic events." ICCSA2014. 2014.

Basic Research-Thrust Area 3-Topic H6: Global Redox Changes as Indicators of CBR Exposure

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: Chemical dialogues routinely occur in biological systems and serve the purpose of providing important communication links within and among cells. Those dialogues are often mediated by oxidation-reduction (“redox”) reactions, where information is transmitted by diffusible signaling molecules (e.g., NO and peroxides) and received by atomically-specific receptor moieties. Although redox-active species serve many beneficial purposes in biological systems, accumulation of reactive oxygen species (ROS) and reactive nitrogen species (RNS) within the cell has been associated with mutation, carcinogenesis, disease, inflammation, and aging. Oxidative stress has been defined as “an imbalance in prooxidants and antioxidants with associated disruption of redox circuitry and macromolecular damage” and has been shown to

result from exogenous perturbations, including those mediated by chemical agents, biological agents, and radiation (CBR), that cause cells to release ROS and RNS into the extracellular matrix. Extracellular release of such radical species in response to CBR can convey precise chemical information to neighboring cells that may prevent or mitigate harm at higher levels of organization (e.g., tissues). Redox changes are thus recognized as cellular "first responders" that can provide early indication of xenobiotic insult.

Although redox changes are associated with a number of toxicological endpoints and human disease states, current metrics of oxidative stress and bioanalytical methods used to characterize molecular redox profiles have not been fully realized. Traditional approaches target transient radical species which are challenging to measure *in situ* with available methodologies. However, recent evidence suggests that redox dysfunction is a nuanced process that is not adequately characterized by simply evaluating local free radical generation and consumption within cells. Further elucidation of the various mechanisms and chemistries underlying redox dysfunction associated with CBR exposure will require tools that allow redox-probing on a more global level, to provide a meaningful basis for relating redox changes to profound cellular insult and incipient disease. Of greatest utility are tools which would permit both rapid and robust measurements of a broad suite of redox-related endpoints that may be reflective of the myriad changes which could contribute to dysfunction while providing datasets that can be used as a foundation for developing fine-tuned analytical methodologies. Although advances in proteomics and metabolomics have led to the discovery of redox-active biomarkers that suggest they could be potential contributors to overall redox dysfunction, those reactions have not been translated into electrochemical analogues that could be used to elucidate redox changes unique to specific CBR threats and to understand how those changes could relate to deleterious health impacts resulting from exposure.

Previous research provides proof-of-concept for use of electrochemical methods to measure total antioxidant activity and to provide a holistic view of the various physiological interactions important to redox dysfunction. Other methods have been applied but may miss important biological information by limiting investigation to one or a few specific targets or because the nature of the analytical technique applied fails to capture redox species in their native states. The present topic seeks research that evaluates and develops electrochemical techniques to probe for global redox information in biological matrices, with a particular focus on methods that could eventually be adapted to point-of-care applications. Such developments can be utilized to yield accurate diagnoses of diseases or syndromes prior to the appearance of notable symptoms.

Impact: If successful, fundamental knowledge of global redox dysfunction could lead to development of small, inexpensive, and easy-to-use diagnostic platforms for point-of-care to evaluate (1) whether exposure to CBR has taken place and (2) identify specific causality prior to onset of symptoms. Pre-symptomatic identification of global redox states associated with CBR exposure will maximize likelihood of success for therapeutic interventions that mitigate latent cellular insult associated with redox dysfunction.

Objective: Investigate means to translate biologically-produced chemical signals into electrical signals amenable for diagnostic evaluation using electrochemical methods. Topic focus is on materials development to broaden the scope of available chemical signatures for further interrogation in terms of establishing relevance to overall redox dysfunction. Competitive proposals will:

- Develop global-level measurement methods for detecting redox changes
- Identify and validate relevant chemical signatures (i.e., "biomarkers") of oxidative stress
- Establish presence of said chemical signatures in standard sample collection matrices
- Demonstrate proof-of-concept for a CBR agent or analogue

Proposals that seek to relate global redox changes to clinically relevant endpoints, such as manifestation of tissue-level damage or particular disease states related to radiation exposure, are of particular interest, although others will be considered. Evaluation of "standard" markers (e.g., ROS or RNS) in the absence of a more global contextual framework that considers relationship to and impact upon overall redox dysfunction is not desirable for the present topic.

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Basic Research-Thrust Area 3-Topic H7: Plasmonics and Nanophotonics for Light Generation, Energy Concentration, and Plasma Generation

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: There is a continuing need for simulators to replicate relevant portions of the nuclear effects spectrum to insure that DoD systems are survivable. Current large scale simulators replicate blast, thermal, X-ray, gamma, and neutron pulses. These above ground simulators are large complex facilities that are expensive to operate and to keep operational. Many of these simulators are only refurbished and utilized for a limited time during strategic system development. The most complex and expensive facilities are those for generating cold and warm pulsed X-rays. These facilities generate x-rays either through Bremsstrahlung conversion of an intense e^- beam (~10 keV to 10000 keV) or by creating an X-ray emitting plasma using either z-pinch pulsed power facilities or high power pulsed laser facilities (0.1-10 keV). Moving beyond large scale above ground simulators for survivability testing requires a fundamentally different approach and scale to energy concentration and light generation.

Nanophotonics and plasmonics have advanced significantly due to advances in modeling and ease of nanoscale device fabrication. Most of this advance has been driven by applications in sensing, near-field imaging, and CMOS compatible optical devices. The same light concentration and field strength enhancement techniques utilized by the plasmonic sensing community have been used to generate gas plasmas, drive high harmonic generation, and increase non-linear quantum yields. While these techniques have achieved extreme UV light and energetic electron generation, it is unknown if these techniques can be driven into spectral regions and pulse intensities necessary to simulate nuclear outputs. Realistic advances could push these techniques into relevant spectral ranges. For example, the 43 harmonic of an 800nm laser pulse using silver nanostructures has been demonstrated. Moving from silver and near IR laser pulses to aluminum and UV (~200-300nm) pulses would push the 43 harmonic into the

250eV range.

Most of the current plasmonics research has focused on reusable nanoscale gold or silver structures excited with low power visible to near-IR light. There has been growing interest in plasmonic structures utilizing aluminum, refractory metals, or 2D materials, such as graphene that could be excited in the UV, handle higher temperatures, or be fabricated into novel structures. While deformation or melting of plasmonic nanostructures have been reported at greater than 0.15 TW/cm^2 illumination, there has been no systematic look at single shot targets or maximum power handling capacities. Modeled hot spot sizes below 100nm are commonly reported. Even moderate laser pulses concentrated to this spot size would have significant energy density. Most plasmonic structures are designed to interact with plane wave light from a single direction. Three dimensional nanostructures may be able to concentrate light from multiple directions to increase the total output.

Impact: Plasmonic and nanophotonic structures may provide an alternative cost effective approach for generating x-ray pulses, thermal pulses, and small plasmas for small scale testing of materials, optics, and devices. Plasmonic and nanophotonic light concentration techniques may also be applicable to large scale pulsed laser facilities.

Objective: To study the limits of plasmonics and nanophotonics for generating plasmas and light pulses relevant to simulating a nuclear explosion output spectrum. Theoretical, modeling, and experimental efforts are of interest. Efforts are not limited to conventional plasmonic materials, conventional excitation wavelengths, or reusable targets. Creative and higher risk approaches to achieving relevant wavelengths and intensities are of particular interest.

Research areas may include, but are not limited to:

- High harmonic generation
- Plasma generation
- High intensity plasmonic thermal emitters
- Multiple source focusing (3D)
- Effect of high laser pulse powers
- Effects of high contrast or shaped laser pulses
- Refractory or other high temperature/high laser power plasmonics

This topic is NOT interested in plasmonic based sensing or imaging.

References:

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Basic Research-Thrust Area 3-Topic H8: System Level Nuclear Survivability Assurance Modeling

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: The Department of Defense has a long history of modeling, predicting, and attempting to assure survivability and reliability of components, systems, and networks. In order to avoid extensive survivability modeling and testing, systems have traditionally been designed using a combination of requirement flow down and established standards/design guidelines. Physics or engineering models of the response of specific components or systems to single insults (e.g. airplane wing damage, blast effect on ships) have also been well developed. More recently there have been a number of efforts looking at modeling the survivability and resilience of networks (e.g. computer, communication), but these models typically do not address the unique challenges of nuclear survivability assurance.

Nuclear survivability models must address the scale of the insult, which can damage multiple or all components simultaneously, as well as multiple overlapping insults, such as blast, thermal, and radiation. These models also need to ideally provide quantitative survivability predictions or

traceable survival assurance. System engineering tools such as Goal Structuring Notation, Model Based System Engineering, and safety/assurance cases have recently been utilized by NASA to assure survivability and mission success for small satellites. These graphical argument notation approaches are promising for transitioning away from prescriptive standards based approaches to objectives oriented approaches, but they still require extensive knowledge of particular parts or sub-systems in order to satisfy the arguments. Bayesian models for survivability and reliability have also been developed to provide more quantitative predictions and to help address variability in parts and systems. It is not clear that either argument based or Bayesian based modeling approaches can provide survivability assurance without extensive part/component testing knowledge.

The actual nuclear survivability of systems is further complicated by variability (both known and unknown), the complex interaction between hardware and software, vast possible state spaces, and the increasing reliance on networked systems or constellations. Variability occurs at the part and component level, even within specific lots, as well as at the system level due to manufacturing variability, upgrades and maintenance, and aging and use. Many modern systems are software controlled including drive-by-wire and fly-by-wire systems. It is difficult to model or test how this software/hardware interaction will perform in nuclear survivability scenarios. Networked or constellation based systems-of-systems should increase the chance that a part of network survives, but the resulting level of performance is often not known.

Updated modeling and simulation approaches for survivability assurance are needed that leverage existing efforts to address the unique challenges of nuclear survivability and begin to address the complexities of modern DoD systems. This includes how to address exposure to natural and artificial radiation (X-ray, gamma, neutron, and electron), electromagnetic pulse (EMP), blast waves, thermal pulses, and combined nuclear insults at the system level.

Impact: System level modeling of nuclear survivability would allow for efficient design and testing of DoD systems to minimize both system hardening and system testing costs, while increasing the accuracy of nuclear survivability assessments and certifications. System level survivability modeling will also allow for timely assessments of the impacts of a nuclear attack on unhardened or rapidly deployed systems.

Objective: This topic seeks to develop quantitative system engineering concepts or overarching approaches for system level nuclear survivability assurance as well as models, simulation constructs, or analytical approaches that address the specific research areas below. Modeling of simplest cases or generic systems may be useful for concept development. This topic also seeks to understand the limits, both practical and theoretical, of proposed approaches for quantifying system level survivability. This is not an effort to develop a specific model for a specific system or specific insult, but rather to develop general approaches toward quantifying survivability, minimizing the required test data, and addressing the system level modeling challenges unique to nuclear events.

While leveraging of work network and cyber survivability modeling is encouraged, this topic is not interesting in network survivability modeling or cyber survivability modeling.

Research areas may include, but are not limited to:

- Modeling effects of part level and system level variation on survivability
- Modeling of combined nuclear insult survivability (e.g. blast and radiation)

- Modeling the interaction of hardware and software for survivability assurance
- Model based quantification of survivability
- Leveraging of current models to add nuclear specific insults
- Modeling of constellation survivability and impact on performance

This topic is NOT interested in modeling the survivability of networks or cyber systems, nor is it interested in reliability modeling.

References:

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Basic Research-Thrust Area 4-Topic H9: Inverse Regression Uncertainty Quantification for High Pressure and High Temperature Environments

Award Amounts for this topic are anticipated to be up to $1,000,000 per year (total dollar value = direct and indirect costs). All efforts must be multidisciplinary. Preference will be given to multi-institution proposals; however, multiple PIs from a single organization are also eligible to apply. Further preference will be given to teams that have a university as the lead organization, maintain significant amounts of research at one or more universities, and include multiple opportunities for training. The proposed award value should be clearly substantiated by the scope of the effort.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: DTRA is interested in developing theoretical constructs for quantifying uncertainties associated with utilizing weapons to neutralize and deny enemy use of WMDs and associated facilities. Prior research has been performed to quantify model and numerical uncertainties using forward propagating uncertainty quantification, including for the effect of understanding turbulence and increasing confidence in neutralization conditions of biosimulants [4]. Uncertainty quantification uses mathematical/statistical methods to determine the uncertainty of input and output parameters. Sources of uncertainty include both epistemic (*i.e.* model uncertainty due to lack of knowledge) and aleatory (statistical uncertainty). For forward propagating uncertainty quantification, input uncertainties are typically propagated through a code to calculate the output uncertainties. Inverse problems which are constrained by observations or data are associated with a greater degree of challenge. Understanding and quantifying uncertainties by constraining with direct observations in gas phase kinetics of simulant decomposition [2, 3], combustion of reactive materials, and failure of solid state media are three general areas that DTRA is interested in exploring quantification and potentially minimization of uncertainties.

Fortunately, diagnostic technologies and methodologies have evolved immensely. The current

generation of diagnostic capabilities may enable quantification of concentrations for biocidal species, initial chemical simulants, intermediates and final products, etc. Given these now tractable approaches and supporting techniques to interrogate these extreme environments, data led approaches to constrain uncertainties are highly valued. Given data limitations in high P-T regimes, coordinated efforts involving some high fidelity experimentation to further guide model optimization are warranted.

Impact: Research in this topical area may increase the degree of confidence in modelling kinetics of neutralization for high temperature chemical reactions involving agent simulants and combustion of reactive materials. This research may increase the overall predictive capability of existing stockpile and next generation agent defeat weapons against biological and chemical threats. Developing a framework and utilizing these tools may eventually lead to enhancements in experimental design at intermediate and large scales, experimental verification and model validation, and may lead to risk based decision making.

Objectives: In order to eliminate undesired collateral effects from utilizing agent defeat weapons, there is a need to quantify uncertainties associated with the underlying physical and chemical processes of an event. The development of quantifying uncertainties using inverse regression raises significant challenges. To deduce inputs to accurately quantify uncertainties from limited data sets, it requires the development of a multi-scale inverse framework. Knowledge of inputs can then be used to make predictions to gauge accuracy from limited data or to devise control strategies based on predictions. Due to some current data set limitations, the theoretical construct (and following algorithm optimization) is emphasized and may require using existing data sets at lower pressure and temperature. The objective of this topic is to focus on developing a theoretical construct identifying and quantifying uncertainties associated with the three events/processes below.

Research areas may include, but are not limited to:

- Primary Objective: Uncertainty identification and quantification in fireball chemistry [1] - Decomposition and kinetics of gas phase chemical simulants at high temperature (up to ~2000 °C) and heating rates in (primary) high and low oxygen environment and (secondary) with halogenated species using experimental observables such as long wave infra-red(LWIR) absorption, ignition delays of simulants etc.
- Primary Objective: Combustion of Reactive Materials under fast heating and detonation conditions – research in solid state reactive materials dispersed into mixed phase products could focus on connecting experimentally observed parameters such as temporal histories of pressure, temperature, combustion efficiency, and concentration of halogenated species to uncertainties in characteristic details of thermitic or pyrotechnic materials in powder form.
- Secondary Objective: Uncertainty quantification associated with failure and fracture of solid state media (e.g. sand, cement, etc.) under shock loading using temporal histories and temporally integrated data including velocity interferograms, x-ray radiographs, and debris analysis.

References:

[1] Broad Agency Announcement: Period E – Topic 11: “Chemistry of Chemical Agents, Simulants, and Precursors”.

[2] Burke, M. P; (2016) Harnessing the Combined Power of Theoretical and Experimental Data through Multiscale Informatics; *Int. J. Chem. Kinet*. 48 (4) 212–235. DOI:10.1002/kin.20984.

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Basic Research-Thrust Area 4-Topic H10: Novel Materials with Synergistic Decomposition/Neutralization Mechanisms against Chemical Agents, Simulants and Precursors

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: Suspended, aerosolized and/or liquid (containerized and pooled) chemical agents are neutralized, destroyed or otherwise defeated via a wide variety of techniques including chemicals, thermal impulse and blast. Typically, targeted chemical agent stocks are located in hostile or non-permissive areas in a wide variety of containers and facilities. Airborne munitions are the preferred method of accomplishing chemical warfare agent (CWA) denial. However, these methods have the potential to generate toxic by-products from chemical warfare components during neutralization [e.g. EA2192-S (2-Diisopropylaminoethyl) methylphosphonothioic acid from VX]. Plumes generated by explosively defeating chemical agents can induce and complicate collateral damage by contaminating the surrounding and downwind areas with agents and potentially toxic by-products. Materials that will mitigate the above concern by utilizing synergistic mechanisms of defeat is preferred.

This topic seeks basic research into the development of energetic materials with multi-mechanistic approaches that use high energy density metal/alloy fuels in reactive/energetic materials to neutralize/inactivate agents chemically, thermally and by blast. As an example, metal oxides, which are combustion (or reaction) by-products of some metals, are chemically and thermally capable of initiating CWA (e.g. VX, GD, HD, etc.) degradation in targets.

Impact: Chemical warfare agents have been employed during times of conflict for a century. While there are known therapeutics for many CWAs, they are not readily available nor usable to pre-emptively deal with this threat. Indigenous civilian populations close to a targeted area are at risk of exposure from ejected CWAs, or toxic by-products, after an attack. This research will be a novel, concerted effort to develop the knowledge-base for technological capabilities to deal effectively with the threat and significantly enhance the DoD's ability to neutralize and deny use of CWAs, while protecting surrounding civilian populations. The data generated from this effort should provide insight into the neutralization process which will contribute to the development of novel material formulations.

Objectives: Primarily, this research seeks to support the development of new reactive/energetic materials capable of neutralizing simulants of CWAs, precursors, etc. by impulsive means and through other multi-mechanistic and synergistic pathways.

Research areas may include, but are not limited to:

- Neutralization of CWA's by decomposition reactions such as autocatalytic hydrolysis (hydrolysis of by-products), metal-catalyzed/assisted reactions, use of halogens as nucleophiles initiated by events arising from release of the materials.
- Generate materials that exhibit extreme and long thermal events with optimum over-pressure regimes, possibly with metal oxides generated (as in thermite reactions) for multi-mechanistic neutralization of chemical warfare agents. These materials must have high energy density capable of generating extreme heat on a rapid time scale with long burn times.
- Generate materials that exhibit innovative and novel modalities of chemical warfare agent neutralization. These may include exploration of metal-organic frameworks (MOFs) and polyoxometalates (POMs) to reveal the full mechanism of deactivation during high temperature decontamination.
- Metal-Inorganic-organic materials that deflagrate at high temperatures or under a thermal/pressure pulse to produce chemicals or products that synergistically decompose chemical warfare agents.
- Secondary objective: Explore photocatalytic assistance (materials and mechanisms) such as using photons from high energy sources (e.g. during detonation / combustion / deflagration events) to initiate degradation of agents. For instance, UV with TiO_2 substrate will catalyze oxidation of volatile organics in air at low levels-as used in air cleaners.

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Oxidation of Chemical Warfare Agents and Application to CFD Simulations".

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Basic Research-Thrust Area 5-Topic H11: Exploring Fundamental Mechanisms and Predicting Properties of New Adsorbent Materials for Collection of Radionuclide Gases

Award Amounts for this topic are anticipated to be between $150,000 and $350,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $350, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

Proposals from Young Investigators will be considered for this topic. Young Investigator proposals should be clearly marked as such and include a scope of work commensurate with a $100,000 award (total dollar value = direct and indirect costs). Young Investigators are defined as individuals who are currently employed by a U.S. accredited degree-granting college or university who received a Ph.D. or equivalent degree within five (5) years of the date of the pre-application white paper submission. Pre-application white papers and proposals from Young Investigators will be given preference.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: Detection of radioactive signatures is a key capability for discriminating between a suspected underground nuclear weapon test, and a nonnuclear event, e.g. geologic event. Radioisotopes released from a nuclear explosion can take the physical form of either particulates or gases. Unfortunately, few radioisotopes from an underground event are released into the

atmosphere or hydrosphere, which results in only trace quantities reaching the detectors. Noble gases, which have very low reactivity, have the highest chance of escape compared to particulates and other gases, and thus the highest probability of detection. Therefore, this topic limits consideration to gas modalities, and the search for materials that better collect them.

Adsorbents are used in radionoble gas monitoring, such as the collection of radioxenon isotopes. Difficulties arise from the low concentrations of radionoble gases coupled with their unreactive nature. Natural zeolites (e.g., chabazite with varying silver percentage) are one family of materials studied as alternatives to activated charcoal. Investigations are needed to model and theoretically, or experimentally, predict or discover families of materials with better potential for use as adsorbents. This includes understanding factors such as the effect of pore size, affinities introduced to sites, surface area, additional trap mechanisms, how to reverse binding mechanisms to release captured gases, moles per gram that can be retained, temperature and pressure effects, and understanding what may cause alteration and degradation over time of materials properties.

Research is needed, for example, to better understand the mechanisms by which silver adds to adsorption in some cases and less so in other zeolites. Research should investigate what else is possible besides silver zeolite, but go beyond ad hoc material identification. Basic research should help understand the systematic variations in adsorption as a function of fundamental mechanisms involved. Furthermore, in addition to adsorption mechanisms research is sought to help understand if alternative mechanisms (e.g., ligands) can serve to capture isotopes or elements of interest. Research is needed to identify and characterize properties of the most important mechanisms to understand that will guide prediction of new families of adsorbents.

Impact: The collection of radionuclides is important for treaty monitoring and the verification process. The International Monitoring System (IMS), for example, includes detector stations for radioisotope collection and identification in addition to seismic detection. The importance of collection materials with greater adsorption is that more efficient and rapid collection is helpful for better collecting plumes that transit a detector for a limited period of time. Although some materials have been developed and used for collecting radioxenon, materials to collect additional species such as radioargon are just in their infancy. Successful basic research would help expand knowledge of the phenomenology of the materials collection processes, and enhance future collection capabilities across multiple radionoble gases by enabling optimum materials design.

Objective: Studies are sought that will promote understanding of how to predict radionoble gas collection property improvements as material composition varies. A theoretical basis for a better understanding of promoting adsorption or binding is sought in addition to experimental verification of absorption or trapping trends among material candidates. This topic seeks understanding of fundamental mechanisms that lead to predicting and potential discovery of advanced materials to improve the collection methods for radioxenon isotopes and other gas types such as radioargon.

Research areas may include, but are not limited to:

- Conduct modeling efforts and theoretical analyses to understand how fundamental adsorption or additional binding mechanisms improve collection as material compositions are varied. Also of interest is understanding processes which release the captured gas atoms, and what mechanisms might favor such processes.

- Investigate fundamental mechanisms in novel synthetic zeolite materials that can selectively trap gases such as xenon or argon. Improve understanding of the physical interactions of silver in Ag-chabazite variants, and theoretically investigate whether other impurities could achieve similar results.
- Investigate fundamental mechanisms in novel Metal Organic Frameworks that can selectively trap gases such as xenon or argon. Explore selective trapping of gas species. Promote understanding of use of ligands for capture of radionoble gas.
- Theoretical prediction of additional types of materials that can exploit "cage" molecular structures. These may include variations on fullerenes, and nanotubes, adsorbing or intercalating clay structures, or other means for selectively capturing xenon or argon. Understand mechanisms such as molecular trapdoors, sieves, or other approaches to capture radionoble atoms.
- Explore the potential and limitations of capturing other products such as the decay species from xenon or argon. Include understanding of background, reactivity challenges, and when such detection may give reasonable S/N.

Basic Research-Thrust Area 7-Topic H12: Design Rules for Biomimetic Enzymes and Binders

Award Amounts for this topic are anticipated to be between $350,000 and $500,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $500, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: DTRA seeks to understand the *de novo* design rules for constructing biomimetic enzymes and binders (a.k.a., synthetic macromolecules) with protein-like binding and catalytic function from non-standard building blocks (e.g., other than the 22 standard amino acids). In recent years, natural peptides and proteins have been explored for their utility in combating chemical and biological threats. However, these modified peptides have not been able to be optimized, and are prohibitively expensive and too fragile to use in harsh battlefield environments for chemical or biological diagnosis, detection, therapeutic treatment, or decontamination. In the past decade, advances in the field of biomimetics and computational sciences have amassed a wealth of information on structure-function relationships and researchers have used this knowledge for *de novo* construction of enhanced peptides and hybrids. Further advancement in design principles present a unique opportunity to develop a deeper understanding for *de novo* construction of biomimetic enzymes and binders with protein-like function that are small (e.g., can integrate into porous networks), exhibit rapid turn-over rates,

high affinity binding and specificity and are able to function in the presence of extreme environmental factors (e.g., temperature, humidity, acidity, organic solvents).

Impact: Successful *de novo* design and optimization would lead to highly efficient, thermostable, customizable biomimetic enzymes or binders for detection or decontamination of chemical and biological threats.

Objective: This research topic seeks to develop rational design approaches for construction of small (<5KDa), robust, predictable and cost effective biomimetic enzymes and binders for destruction of chemical warfare agents. The research should propose an iterative (spiral) approach to understand the underlying structure-activity and structure-stability relationships and confirmation of the biomimetic enzyme's or binder's effectiveness on simulants and/or live agents. The research should be targeted to inform design of robust biomimetic enzyme or binders with high specificity, sensitivity and affinity to break-down agents with rapid turnover rates under ambient conditions, and are stable under extreme conditions, mixed solvents or reaction byproducts. A requirement for the topic includes demonstrating an adequate understanding of the relationship between design and function through the expedient use of predictive *de-novo* computational design tools to alter the specificity of a biomimetic enzyme or binder, or design an enzyme able to catalyze a reaction that naturally does not proceed to completion (e.g., esterification of organic acids with alcohols). Ideally, these biomimetic enzymes and binders (a.k.a., synthetic macromolecules) could be complexed to build highly predictable and controllable biomimetic macromolecules (or platforms onto which biotic functionalities are appended) able to detect or decontaminate multiple biological and chemical agents.

Proposals offering only theoretical approaches (e.g., modeling) or modification of a protein composed of the 22 standard amino acids will not be entertained.

Research areas may include, but are not limited to:

- Studies of highly efficient mechanisms of interactions between a biomimetic enzyme or binder with targets (e.g., binding, transition state stabilization, product release);
- Molecular level interrogation of the interactions between a biomimetic enzyme or binder with a substrate (to include metals, as applicable);
- Design principles for imparting small size and high stability against time, heat, mixed solvents, and byproducts.

Basic Research-Thrust Area 7-Topic H13: Determining the Fundamental Differences Between In Vitro and In Vivo Test Models

Award Amounts for this topic are anticipated to be between $350,000 and $500,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $500, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that

outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: Scientific research and development activities are quickly shifting toward using 3D- and dynamic-cell cultures (e.g., organoids, tissue-on-a-chip) to understand how drugs and toxicants operate in the human body. This effort strives to unearth the basic molecular differences between these types of cell cultures and human physiology.

Knowledge gaps within, and between, *in vitro* and *in vivo* test platforms plague the chemical and biological defense enterprise. For example, studies show that rodent and non-rodent species are predictive for only 43 percent and 63 percent, respectively, of human toxicity [2], highlighting a stark species difference. On the *in vitro* level, three-dimensional cell culture advancements (i.e., organ-on-a-chip, organoids, etc.) show potential in disrupting toxicological assessment, drug discovery and development, and detection processes. However, little is known on the degree in which *in vitro* experimental platforms from different animal species correlate with whole animal, and further, with the human condition.

This topic focuses on understanding the basic biological differences amongst species (*in vivo* and *in vitro*) in the face of a toxic agent or drug, and how these experimental platforms coincide with humans and human experimental platforms (e.g., human liver on a chip). Compounds known to cause toxicity or pharmacological action through specific protein targets/receptors are of primary concern for this topic. Methods for extrapolating specific acting agents or drugs requires a robust assessment that takes into account additional species differences, including, but not limited to: receptor density in sensitive organs; genotypic changes; and metabolic clearance and other ADME differences. Although *in vivo* toxicology and pharmacological data provides critically relevant physiological data, model representation does not consistently reflect human response (e.g., human toxicity estimate). This topic strives to fill the knowledge gap between *in vivo* and *in vitro* test models, which could help to better inform DoD and U.S. Government interagency toxicology, drug development, and detection stakeholders.

Impact: Inherent in this work is the opportunity to identify molecular level changes due to challenge(s). Modern molecular biology can routinely screen across the entire genome to observe changes in, for example, the regulation of peptides and proteins. These changes have the potential to provide a biological signature for identification of exposure and/or the efficacy of a toxic agent or therapeutic. Although this is not the main objective of this Topic, these types of studies in conjunction with the primary work is encouraged.

If successful, this effort will support the RD-CBS predictive toxicology program and RD-CBM work flows by reducing, refining, and replacing a number of scientific experiments. A long term benefit would be reduced costs and time to deliver pertinent toxicological and drug development data. The outputs will also inform the selection of appropriate models for *in vivo* acute toxicity testing of unknown chemicals and toxins. This will enable the DoD to start validating these novel research tools to fully understand their capacity to inform the DoD of human physiology as related to chemical and biological defense.

Objective: This topic solicits proposals that will address, compare, contrast, and translate toxicological and pharmacological information derived from *in vitro* testing platforms to,

ultimately, better understand and inform human health-based risk assessments (i.e., efficacy, absorption, distribution, metabolism, etc). Preference will be given to those performers who utilize three-dimensional organoids and/or organ-on-a-chip technologies that are representative of animal models, who correlate the test platforms directly with human physiology. It is paramount that the research focus on chemical and biological defense-related needs and relevant drugs or chemical compounds. Use of high-throughput techniques such as high-throughput sequencing, metabolomics/proteomics, and computational assessments are encouraged, but are not required. At the conclusion of this effort, a culmination of *in vitro* data sets and statistical comparisons to human physiology will be assessed and reported. The end state will be a packet of data that can be delivered to the FDA for a type C meeting.

References:

[1] Knight A. (2007) Animal experiments scrutinized: systematic reviews demonstrate poor human clinical and toxicological utility. ALTEX 24: 320-325.

[2] Olson H, Betton G, Robinson D, Thomas K, Monro A, et al. (2000) Concordance of the toxicity of pharmaceuticals in humans and in animals. Regul Toxicol Pharmacol 32: 56-67.

Basic Research-Thrust Area 7-Topic H14: Elucidating Design Rules in Nanoporous Materials for Destruction of Chemical Warfare Agents

Award Amounts for this topic are anticipated to be between $350,000 and $500,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $500, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Goal: To uncover rules for optimal design of nanoporous catalytic architectures to degrade CWAs.

Background: Over the last decade, we have been exploring a wide variety of nanoporous heterogeneous catalyts to degrade CWAs. This body of work demonstrated the importance of linker size/pore size on degradation kinetics of soman [3], chemical functionality on degradation kinetics of VX [2], and accessibility of catalytic sites [1] etc., on zirconium based metal organic frameworks. More recently, we have gained insight into reaction mechanisms within active sites and have developed a better understanding of the energetic landscapes reflecting changes in the chemical and electronic surface environment through in-operando techniques. For example, a great deal of insight has been gained investigating the tailorability and topological diversity of Metal Organic Frameworks (MOFs). In order to truly understand how to design materials with

enhanced reactivity, we need to understand the role of mass transfer in these systems, and how topology affects reactivity. There exists an opportunity to elucidate the inter-dependencies between topology and diffusion in order to define the design rules for optimal design of nanoporous catalytic architectures.

Impact: The research under this topic would enable understanding of the impact of structural properties of nanoporous materials on enhanced reactivity; guiding design of efficient local structures for catalysts at the molecular level with improved transport kinetics. This research will help bridge the gap between theoretical simulation and proof of concept experiments to real-word applications.

Objective: The objective of this topic is to study the overall degradation process of CWAs within materials as a function of topology in order to elucidate design rules for efficient synthesis of nanoporous materials with enhanced degradation kinetics. Parameters that are of value include molecular transport, adsorption, diffusion, reactivity and desorption. The ultimate goal of this work would be to define design criteria for the development of more sophisticated material capable of rapidly and efficiently degrading CWAs.

Research areas may include, but are not limited to:

- Experimental measurements of diffusivities and theoretical prediction of transport properties of CWAs or chemically and physically similar simulants to determine the dependence of diffusion on topological parameters. New methods or techniques may be explored, especially if measuring live agents.
- Studies of catalytic activity as a function of topology using state of the art techniques and methods to examine, for example, impact of crystal size, structural dimensionality (e.g., inter-connectivity of sub-space, surface area, and cage topology), or functional groups on uptake, transport, and activity. New methods and techniques may be explored, especially if measuring live agents.
- In silico modelling of structures with optimal topology for binding/ catalysis of organophosphorus nerve agents.
- Modelling sorption isotherms for CWA, water, and other chemical that might compete to determine optimal topology.
- Synthesis of structures with optimized topology for capture and destruction of CWAs or chemically and physically similar simulants.

References:

[1] Mondloch, Joseph E., Michael J. Katz, William C. Isley III, Pritha Ghosh, Peilin Liao, Wojciech Bury, George W. Wagner et al. "Destruction of chemical warfare agents using metal–organic frameworks." Nature materials 14, no. 5 (2015): 512-516.

[2] Moon, Su-Young et. al. Effective, Facile. "Selective Hydrolysis of the Chemical Warfare Agent VX Using Zr6-Based Metal-Organic Frameworks." Inorganic Chemistry, (2015): 10829-10833.

[3] Peterson, Gregory W., Su-Young Moon, George W. Wagner, Morgan G. Hall, Jared B. DeCoste, Joseph T. Hupp, and Omar K. Farha. "Tailoring the Pore Size and Functionality of UiO-Type Metal–Organic Frameworks for Optimal Nerve Agent Destruction."

Inorganic chemistry 54, no. 20 (2015): 9684-9686.

Basic Research-Thrust Area 7-Topic H15: Evaluating the Human Metabolism of Chemical Warfare Agents

Award amounts for this topic are anticipated to be between $500,000 and $750,000 per year (total dollar value = direct and indirect costs). In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

The preferred award structure for this topic is a base period of two (2) years with up to two (2) additional years as possible options. However white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Note that white papers and proposals that outline scope and effort that exceed a total of four (4) years will not be considered.

Background: The toxic effects of organophosphorus compounds (OPs) relating to their binding to acetylcholinesterase (AChE) are well known. These actions result in a variety of symptoms in humans and animals which can include difficulty breathing, nausea, salivation, lacrimation, and seizures. Post-exposure treatment traditionally includes atropine and 2-PAM injections for affected personnel. In addition, pretreatment with pyridostigmine bromide has been approved for Soman exposure (and possibly other nerve agents).

Metabolism of xenobiotics by the human body primarily utilize the Phase I and Phase II enzyme systems. Phase I enzymes are typically the cytochrome P450 monooxygenases (CYPs) and flavin monooxygenase (FMO). Phase II are the enzymes involved in hydrolysis, acetylation, glucuronidation, sulfation, and several other metabolic activities. Xenobiotics are metabolized via these different enzymatic steps resulting in increasingly soluble metabolites that are primarily eliminated in the urine.

Several studies have addressed the metabolism of organophosphorus compounds, and other related environmental chemicals. Cytochrome P450 monooxygenases, and flavin monooxygenase have been identified as playing a significant role in metabolism of organophosphorus, and related, chemicals (Hodgson et al., 2007a, Foxenberg et al., 2007, Hodgson et al., 2007b). Specifically, P450 enzymes CYP1A2, 2B6, 2C9, 2C19, 3A4, 3A5 and 3A7 have been identified as being active against organophosphorus compounds (Foxenberg et al., 2007). However, very little work has been carried out recently, and almost no work has been done to identify how chemical warfare agents are metabolized in the human body. It is likely that the same CYPs are involved in the metabolism of organophosphorus CWAs in the human body

Impact: Identification of the Phase I and II enzymes involved in metabolism of OPs would provide valuable information relating to how the human body metabolizes and eliminates CWAs from the system. This information can be used to predict how various CWAs are removed from the human body. Once this process is better understood, therapies can be developed targeting the metabolic mechanisms in the human body and utilize them to help clear CWAs more quickly.

Objective: This topic solicits proposals which focus on both identifying the Phase I and Phase II enzymes involved in the metabolism of chemical warfare agents and the regulatory mechanisms that control the levels of these CYP enzymes.

The research should initially utilize *in vitro* studies that will study metabolism of CWAs using any of a variety of model systems. This should result in the identification of the metabolic pathways involved in elimination of CWAs from the human body.

Once the Phase I and II enzymes involved in CWA metabolism are identified, the mechanisms that control the enzyme levels would be studied. Many of the regulatory processes involved in controlling the levels of metabolic enzymes in the human body are known. For the CYP450 enzymes, the nuclear receptors Aryl Hydrocarbon Receptor (AhR), Pregnane X Receptor (PXR) and Constitutive Androstane Receptor (CAR) control the majority of the induction (increased enzyme levels) mechanism (Tompkins et al., 2007). Conditions that regulate inhibition of Phase I and II enzymes are also known.

In addition, the effects of CWA exposure on metabolic processes in the human body will be studied with a goal of identifying biomarkers that correlate with CWA exposure.

Developing a body of knowledge relating to how the human body addresses the metabolism and elimination of CWAs will be an important step toward identifying and testing new approaches to treating a person who has been exposed to CWAs; both post-exposure and prophylactically. The information will also allow for identification of biomarkers that correlate with CWA exposure.

References:

[1] FDA Guidance for Industry: Drug interaction studies – Study design, data analysis, and implications for dosing and labeling. 2006.

[2] Foxenberg, R.J., B.P. McGarrigle, J.B. Knaak, P.J. Kostniak, and J.R. Olson. 2007. Human hepatic cytochrome P450-specific metabolism of parathion and chlorpyrifos. Drug. Metab. Disp. 35:189-193.

[3] Hodgson, E. and R.L. Rose. 2007a. Human metabolic interactions of environmental chemicals. J. Biochem. Mol. Toxicol. 21:182-186.

[4] Hodgson, E. and R.L. Rose. 2007b. The importance of cytochrome P450 2B6 in the human metabolism of environmental chemicals. 113:420-428.

Basic Research-Thrust Area 7-Topic H16: Novel Reactive, Porous, and Processable Polymers for Chem-Bio Defense

Award Amounts for this topic are anticipated to be between $350,000 and $500,000 per year (total dollar value = direct and indirect costs). Larger value efforts (i.e., $500, 000 per year) that are university led, include multiple PIs (at either a single or at multiple organizations), and provide training opportunities are encouraged. In all cases, the proposed award value should be clearly substantiated by the scope of the effort.

The preferred award structure for this topic is a base period of three (3) years with up to two (2) additional years as possible options. However, pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered; however, note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: In order to afford protection against chemical and biological warfare threats, porous materials such as carbon, metal-organic frameworks, and polyoxymetallates, have been added to fabrics to absorb and catalytically degrade chemical warfare agents. Although powders/individual materials have been shown to be efficient and useful in practice for the DoD, using, applying, or adhering these additives to polymer fibers/fabrics is difficult. Maintaining functionality of the additives once embedded in the polymers presents an additional challenge.

One potential new area of research is porous, potentially sorptive, and processable polymers having porosity and reactivity towards CWAs. The challenge of this research topic lies in exploring the ability to change the chemistry of the backbone and/or side groups of porous polymers/co-polymers with functional chemistries that will react with CWAs. A second challenge will be to tune the functional/reactive groups or linkers to maintain physical properties of the polymeric substrate including porosity, processability, and desirable mechanical properties. Processability refers to the polymer's ability to be processed through conventional polymer processing techniques, such as film forming, extrusion, wet/dry spinning, etc.

An example of porous, processable polymers are polymers of intrinsic microporosity [3] (PIMs). However, it is not known whether PIMs or similarly porous polymers can be modified to be CWA reactive. There is a large body of literature on reactive polymers, such as nucleophilic polymers with reactivity toward CWA [1, 2]. Therefore, it is of interest to understand how adding some functionalities, either through mixing or synthetic methods, will affect the porosity and processability of the polymer. Chemistries are not limited to PIMs and PIM derivatives; other high free volume polymers are also of interest. Multiple strategies within one proposal to either modify monomers or post-synthetically modify polymers are highly encouraged, as well as synthesis of new polymers. Lastly, the purpose of this topic is to identify strategies to modify polymers to display micro/mesoporosity and understand the effects of the modified polymer with respect to reactivity and processability. So while future studies involving porous materials such as carbon, MOFs, and POMs with polymers is possible, the current topic focuses on strategies of synthesizing and/or modifying porous polymers with self-detoxifying capabilities.

Impact: The research explored in this topic seeks to develop porous, processable polymers with reactive moieties that would be able to serve as functional materials for individual and collective protection, with the ability to sorb and react with CWAs without use of fillers and additives.

Objective: This research topics seeks to discover monomer building blocks and resulting polymers with self-reactive materials for chem-bio defense applications. This research should be targeted to inform routes of synthesis of porous polymers and/or component monomers with CWA-reactive moieties; to include studies that determine the impact on polymer function of a chosen synthetic route. Characterization of processing should not be limited to film casting, extrusion, dry/wet spinning, etc. Quantifiable mechanical testing such as (but not limited to) tensile and three-point bend should be included. Ideally, this research will translate to incorporation of functional polymers into porous polymers at the laboratory scale, and synthesis of the resulting polymers at the lab scale.

Research areas may include, but are not limited to:

- Interrogation of the impact of synthesis on the physical, mechanical and functional characteristics of polymers for synthetic modification strategies;
- Studies of the attributes that lend stability to a polymer under various conditions;

- Predictive modeling of interaction between amorphous polymers and the added reactive moiety with relation to structure-activity processing.

Focus of proposals should be on developing new polymer material and its characterization, and not combining existing materials such as MOFs or other adsorbents into polymers to form composites. Finally, simplicity in synthetic approach is paramount for potential follow-on manufacturing and potential scaling of the synthetic pathway, as new polymers with desired properties could be candidates for transition to a product.

References:

[1] G. Bengtson, S. Neumann, V. Filiz, *Membranes* 2017, 7, 28.

[2] L. Bromberg, W. R. Creasy, D. J. McGarvey, E. Wilusz, T. A. Hatton, *ACS Appl. Mater. Interfaces* 2015, 7, 22001

[3] L. Chen, L. Bromberg, T. A. Hatton, G. C. Rutledge, *Polymer* 2007, 48, 4675.

[4] N. B. McKeown, P. M. Budd, *Chem Soc Rev* 2006, 35, 675.

ATTACHMENT 2: INTELLECTUAL PROPERTY

(Applies to FAR Contracts & OTAs)

Applicants must describe any limitations on the use of any intellectual property (patents, inventions, trade secrets, copyrights, trademarks, technical data or computer software) that will impact the offeror's performance of the contract or impact the Government's subsequent use of any deliverable under the contract. In particular, the applicant must describe the intellectual property in sufficient detail and describe the limitations on its use (potential patent licenses required by the Government, data assertions of the offeror or any subcontractor, etc.) and describe how the Government can accomplish the stated objectives of this BAA with the limitations described or proposed by the offeror.

Patents. Applicants must list any known patents, patent applications, or inventions which the offeror may be required to license in order to perform the work described in the Applicant's proposal, or which the Government may be required to license to make or use the deliverables of the contract should the Applicant's proposal be selected for award. For any patent, patent application or invention listed, the Offeror must provide the invention title, a summary of the invention, patent number, patent application publication number, or provisional patent application number, and indicate whether the offeror is the patent or invention owner. If a patent or invention is in-licensed by the offeror, identify the licensor.

If any listed patent, patent application or invention is owned or licensed by the applicant, the applicant must provide a statement, in writing, confirming that it either owns or possesses the appropriate licensing rights to patent, patent application or invention to perform the work described in the proposal and/or to grant the Government a license to make or use the deliverables for this program. If any listed patent, patent application or invention is not owned or licensed by the applicant, then the applicant must explain how it will obtain a license, how the Government may obtain a license and/or whether the offeror plans to obtain these rights on behalf of the Government.

Be advised that no patent, patent application, or invention disclosure will be accepted if identified in the Data Rights Assertion list. **The list of patents, patent applications, and inventions of this section must be a separate list from the Data Rights Assertion list.**

Government rights in any technology that might be invented or reduced to practice under the contract are addressed in the patent rights clause to be included in the contract.

Data Rights. Applications submitted in response to this BAA shall identify, to the extent known at the time an offer is submitted to the Government, the technical , the technical data, or computer software that the Offeror, its subcontractors or suppliers, or potential subcontractors or suppliers assert should be furnished to the Government with restrictions on use, release, or disclosure, in accordance with DFARS 252.227-7017, Identification and Assertion of Use, Release or Disclosure Restrictions, and DFARS 252.227-7028, Technical Data or Computer Software Previously Delivered to the Government. The applicant's assertions, including the assertions of its subcontractors or suppliers, or potential subcontractors or suppliers, shall be submitted in the following format, dated and signed by an official authorized to contractually obligate the applicant. If the applicant will deliver all technical data and computer software to the Government without restrictions, enter "NONE" in this table under the heading "Technical

Data or Computer Software to be Furnished with Restrictions."

Identification and Assertion of Restrictions on the Government's Use, Release, or Disclosure of Technical Data or Computer Software.

The applicant asserts for itself, or the persons identified below, that the Government's rights to use, release, or disclose the following technical data or computer software should be restricted:

Technical Data or Computer Software to be Furnished with Restrictions*	Basis for Assertion**	Asserted Rights Category***	Name of Person Asserting Restrictions****
(LIST)*****	(LIST)	(LIST)	(LIST)

*For technical data (other than computer software documentation) pertaining to items, components, or processes developed at private expense, identify both the deliverable technical data and each such item, component, or process. For computer software or computer software documentation identify the software or documentation.

**Generally, development at private expense, either exclusively or partially, is the only basis for asserting restrictions. For technical data, other than computer software documentation, development refers to development of the item, component, or process to which the data pertain. The Government's rights in computer software documentation generally may not be restricted. For computer software, development refers to the software. Indicate whether development was accomplished exclusively or partially at private expense. If development was not accomplished at private expense, or for computer software documentation, enter the specific basis for asserting restrictions.

***Enter asserted rights category (e.g., government purpose license rights from a prior contract, rights in SBIR data generated under another contract, limited, restricted, or government purpose rights under this or a prior contract, or specially negotiated licenses).

****Corporation, individual, or other person, as appropriate.

*****Enter "none" when all data or software will be submitted without restrictions.

Date _____
Printed Name _____
Printed Title _____
Signature _____

Applicants responding to this BAA requesting an Other Transaction or Other Transaction for Prototype shall specifically identify any asserted restrictions on the Government's use of intellectual property contemplated under those award instruments. For this purpose, offerors must propose specific Intellectual Property terms and conditions and a data deliverable list. Further, the offerors must explain why an Other Transaction is necessary and, in particular, how the intellectual property terms and conditions proposed will meet the objectives of this BAA.