DEFENSE THREAT REDUCTION AGENCY

BROAD AGENCY ANNOUNCEMENT

HDTRA1-11-16-BRCWMD-BAA

Amendment 4 (December 2014)

Research and Development Directorate

Basic and Applied Sciences Department

Basic Research for Combating Weapons of Mass Destruction (C-WMD)

Original Posting Date: March 2011

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OVERVIEW INFORMATION

1. Federal Agency Name:

   Defense Threat Reduction Agency (DTRA)
   Research and Development (R&D) Enterprise
   Basic and Applied Sciences Directorate
   8725 John J. Kingman Road
   MS 6201
   Fort Belvoir, VA 22060-6201

2. Funding Opportunity Title:

   FY2011 – 2016 Basic Research for Combating Weapons of Mass Destruction (C-WMD) Broad Agency Announcement (BAA)

3. Announcement Type:

   The BAA, which is in effect from March 2011 through September 2016, established the multi-year process and served as the announcement for the first round of submissions (referred to as "periods").

   Over this timeframe there will be multiple opportunities/periods to electronically submit research ideas. Each period will have a two-phased submission process. *Phase I* is the pre-application white paper submission and is open to all qualified entities; *Phase II* is an invitation-only full proposal submission resulting from Phase I pre-application white paper review as decided by the DTRA Selection Authority.

   This Amendment alerts applicants to several administrative updates to the BAA and serves as the announcement for the next round of submissions.

4. Funding Opportunity Number:

   HDTRA1-11-16-BRCWMD-BAA

5. Catalog of Federal Domestic Assistance (CFDA) Number:

   12.351

6. Dates:

   This BAA will have multiple, consecutive opportunities/periods which are not predetermined; however, it is anticipated that there will be at least one opportunity for each year announced in the December timeframe; there may be additional opportunities/periods in any year. Subsequent submission opportunities/periods with corresponding topics, application packages, applicable deadlines, will be published via amendments to this BAA.

The Phase I (pre-application white paper) and Phase II (invitation-only proposal) submission deadlines are/will be shown in Table 1 (below and in Section IV.3.3). The Tables will be updated (by amendments to this BAA) as changes are made to the schedule.

All submissions (pre-application white papers and invited proposals) must be made in accordance with the submission instructions in this BAA through Grants.gov using the application packages provided with this BAA. Applicants are responsible for ensuring compliant and final submission of their Phase I pre-application white papers and Phase II 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.

Date	Event
Period E	
1 December 2014	Amendment to the BAA announced on Grants.gov with Period E topics, application packages, and applicable deadlines
30 January 2015	Phase I pre-application white paper receipt deadline
11:59pm EST, Not prior to 3 April 2015, and not later than 1 May 2015 *	Phase II invitation-only proposal receipt deadline
October—December 2015	Period E Grants scheduled to be awarded

Table 1: List of important dates. (This is a condensed version of Table 5, located in Section IV.3.7.)

ADDITIONAL OVERVIEW CONTENT

This BAA is focused on soliciting **basic research** projects that support the DTRA mission to safeguard America and its allies from WMD (e.g., chemical, biological, radiological, nuclear, and high-yield explosives) by providing capabilities to reduce, eliminate, and counter the threat and mitigate its effects. To this end, DTRA seeks research across broad strategic thrust areas:

- ***Science of WMD Sensing and Recognition***
- ***Cognitive and Information Science***
- ***Science for Protection***
- ***Science to Defeat WMD***
- ***Science to Secure WMD***

Detailed descriptions of these thrust areas can be found in Section I.3. The specific research opportunities (topics) for each period that align to these thrust areas are listed in Section VIII. Research topics are only valid for the submission period in which they are posted, and only pre-application white papers responsive to the topics posted for a given submission period will be considered.

Resulting awards from this announcement will be **grants only**. These grants will be paid in advance, subject to the conditions described in 2 CFR 215.22(b).

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. Terms and conditions of new awards made after December 26, 2014 may include revisions to reflect DoD implementation of new OMB guidance in 2 CFR part 200, "Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards."

I. FUNDING OPPORTUNITY DESCRIPTION

I.1. This BAA is an extramural endeavor that combines basic research needs of DTRA and the Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD) to address the full spectrum of counter-WMD challenges. Both DTRA and JSTO-CBD share the mission to safeguard America and its allies from WMD and provide capabilities to reduce, eliminate, and counter the threat and effects from chemical, biological, radiological, nuclear, and high-yield explosives. Each seeks to identify, adopt, and adapt emerging and revolutionary sciences that may demonstrate high payoff potential to counter-WMD threats.

I.2. This announcement solicits pre-application white papers for long-term challenges in specific fundamental areas of basic research that offer a significant contribution to the current body of knowledge or further the understanding of phenomena and observable facts and may have impact on future capabilities that support the DTRA and JSTO-CBD missions. Responses to this BAA must address **only basic research**. Pre-application white paper and proposal submissions that address applied research, advanced technology development, or combine basic research with applied research and/or advanced technology development will be considered not responsive and will not be evaluated further.

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.[1]

In contrast to basic research, applied research is the systematic study to understand the means to meet a recognized and specific need. It is a systematic expansion and application of knowledge to develop useful materials, devices, and systems or methods. The boundary between basic research and applied research occurs at the point when sufficient knowledge exists to support a hypothesis involving a specific application.[2]

[1] DoDI 3210.1, September 16, 2005

[2] DoD Financial Management Regulation Volume 2B, Chapter 5

I.3. DTRA seeks unclassified basic research across five major functional counter-WMD research thrust areas. Specific research topics that align to one or more thrust areas are presented in Section VIII. The five thrust area descriptions are outlined below.

- ***Thrust Area 1—Science of WMD Sensing and Recognition:*** The basic science of WMD sensing and recognition is the fundamental understanding of materials that demonstrate measurable changes when stimulated by energy, molecules, or particles from WMD in the environment. This research thrust involves exploration and exploitation of interactions between materials and various electromagnetic frequencies, molecules, nuclear radiation or particles. These interactions and the specific form of recognition they provide are used for subsequent generation of information that provides knowledge of the presence, identity, and/or quantity of material or energy in the environment that may be significant.
- ***Thrust Area 2—Network Sciences:*** The basic science of network science is the convergence of computer, information, mathematical, networks, natural, and social science. This research thrust expands our understanding of social networks and advances knowledge of adversarial intent with respect to the acquisition, proliferation, and potential use of WMD. The methods may include analytical, computational or numerical, or experimental means to integrate knowledge across disciplines and improve rapid processing of intelligence and dissemination of information.
- ***Thrust Area 3—Science for Protection:*** Basic science for protection involves advancing knowledge to protect life and life-sustaining resources and networks. Protection includes threat containment, decontamination, threat filtering, and shielding of systems. The concept is generalized to include fundamental investigations that reduce consequences of WMD, assist in the restoration of life-sustaining functions, and support forensic science.
- ***Thrust Area 4—Science to Defeat WMD:*** Basic science to defeat WMD involves furthering the understanding of explosives, their detonation, and problems associated with accessing target WMDs. This research thrust includes the creation of new energetic materials or physical approaches that enhance the defeat of WMDs by orders of magnitude, the improvement of modeling and simulation of these materials and various phenomena that affect success and estimate the impact (lethality) of defeat actions, including the assessment of event characteristics using various dynamic analytical methods.
- ***Thrust Area 5—Science to Secure WMD:*** Basic science to support securing WMD includes: (a) environmentally responsible innovative processes to neutralize chemical, biological, radiological, nuclear, or explosive (CBRNE) materials and components;
  (b) discovery of revolutionary means to secure components and weapons; and (c) studies of scientific principles that lead to novel physical or other tags and methods to monitor compliance and disrupt proliferation pathways. The identification of basic phenomena that provide verifiable controls on materials and systems also helps arms control.

I.4. DTRA seeks unclassified basic research ideas that are responsive to the goals and objectives of the topics outlined in Section VIII. The topics labeled "PerE" are only valid for Period E of this BAA. Only pre-application white papers responsive to the topics posted for Period E and submitted by the Period E deadline will be considered. A new list of topics will be posted for subsequent periods with corresponding pre-application white paper due dates. Note that topics from the original solicitation and Amendments 1, 2, and 3, labeled "PerA", "PerB", "PerC", and "PerD" are NOT valid topics for "PerE". Pre-application white papers that address "PerA", "PerB", "PerC", and

"PerD" topics will not be reviewed by DTRA.

II. AWARD INFORMATION

II.1. Resulting awards from this BAA will be **grants only**. These grants will be paid in advance, subject to the conditions described in 2 CFR 215.22(b).

II.2. The period of performance (POP) for the Single Scope Awards, the Multidisciplinary Awards, and the Young Investigator Awards (all types of awards are detailed in Section II.6) may be up to five (5) years. Awards may be for a base period of one (1) year with up to four (4) additional years as possible options, a base period of two (2) years with up to three (3) additional years as possible options, or a base period of three (3) years with up to two (2) additional years as possible options. The base period and option combination(s) will be specifically detailed in each and every topic. Pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable. Additional guidance on the POP may be provided with the topic description or in the letter of invitation for the full proposal. Each of these supersedes the guidance provided here.

II.3. The POP for the Seed Awards will be for one (1) year or less. Seed Awards may not include option years.

II.4. The final number of grants and the amount of funds allocated for each period will be determined after all pre-application white papers and invited proposals are received and evaluated. On average DTRA expects to award 50-75 grants annually for a total grant value of approximately $66M. 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. Terms and conditions of new awards made after December 26, 2014 may include revisions to reflect DoD implementation of new OMB guidance in 2 CFR part 200, "Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards."

II.5. The Government actions under this BAA shall adhere to the requirements of the Department of Defense (DoD) Grant and Agreement Regulations (DoDGARs). DoDGARs can be accessed online at http://www.dtic.mil/whs/directives/corres/html/321006r.htm. See also 32 Code of Federal Regulations (CFR) 22, which can be accessed online at http://ecfr.gpoaccess.gov/.

II.6. There are four (4) categories of awards, which are detailed below. The applicant does not need to specify the type of award sought. It will be inferred by the dollar amount requested and/or the topic to which the pre-application white paper is submitted.

1. Single Scope Awards: Research projects that focus on exploratory aspects of a unique problem, a high-risk approach, or innovative research in subjects with potential for high impact to C-WMD science. Research must support undergraduate, and/or graduate students, and/or postgraduate students.

Single Scope Awards may have Co-Principal Investigators (Co-PIs) and subawards (grants and/or contracts). Single Scope Awards will be made by a single grant to the lead organization. Subawards, including all grants and contracts, are the responsibility of the award recipient; exceptions will not be made.

Single Scope Awards will average $150K per year for DTRA sponsored topics and $250K per year for JSTO-CBD Program sponsored topics. Additional guidance for the average dollar value may be provided in the topic description or in the letter of invitation for the full proposal. Each of these supersedes the guidance provided here.

The predominance of awards will be Single Scope Awards.

2. Multidisciplinary Awards: Research projects that involve a comprehensive program of innovative research in an interdisciplinary area with potential for high impact. The proposed research must involve fundamental contributions in research by multiple investigators from diverse disciplines (proposal **must** be multidisciplinary). Investigators may be from a single institution or multiple institutions. Research must support multiple undergraduate, and/or graduate students, and/or postgraduate students.

   Authors of these pre-application white papers and invited proposals must take great care to clearly outline the impact to C-WMD science that is to be gained from the higher dollar amount investment and justify the scientific contribution from each investigator.

   Proposals submitted under this category must have a single lead organization and single submission for the pre-application white paper and the invited proposal. Multidisciplinary Awards will be made by a single grant to the lead institution. Subawards, including all grants and/or contracts, are the responsibility of the award recipient; exceptions will not be made.

   Multidisciplinary Awards will average $350K per year for DTRA sponsored topics and $500K per year for JSTO-CBD Program sponsored topics. Additional guidance for the average dollar value may be provided in the topic description or in the letter of invitation for the full proposal. Each of these supersedes the guidance provided here.

3. Young Investigator Awards: Research projects that focus on exploratory aspects of a unique problem, a high-risk approach, or innovative research in subjects with potential for high impact to C-WMD science from individuals 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.

   Young Investigator Awards may have subawards; however, subawards that transfer substantive programmatic activity will be considered non-responsive to the Young Investigator topics. Young Investigator Awards will be made by a single grant to the lead organization. Subawards, including all grants and/or contracts, are the responsibility of the award recipient; exceptions will not be made.

   Young Investigator Awards will average $100K per year.

4. Seed Awards: Research projects that focus on the exploratory aspects of a research hypothesis or on the development of a high-risk approach with potential for high impact to C-WMD science.

   Seed Awards may have Co-PIs and subawards. Seed Awards will be made by a single grant to the lead organization. Subawards, including all grants and/or contracts, are the responsibility of award recipient; exceptions will not be made.

   Seed awards will be less than $75K.

II.7. Funding for participation in this program is highly competitive and the cost of proposed research should strictly be maintained in the award amounts outlined for each award type and for each topic. Under no circumstances will awards exceed 10% of the averages as outlined for each award type and for each topic. Exceptions will not be made.

II.8. Subawards (grants and/or contracts) are permitted. Subawards may be used to carry out a portion of the research. In instances where the lead applicant is an accredited degree-granting college and/or university, applicants should note that substantive programmatic activity must be maintained at accredited degree-granting colleges and universities. DTRA will review and consider the proposed subawards for all pre-application white papers and proposals on a case-by-case basis.

II.9. Applications for renewal or supplementation of existing DTRA funded projects are not eligible to compete with applications for new awards.

II.10. The Government will not provide any hardware or software to execute the proposed research. Exceptions will not be made.

II.11. 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 or fully fund any or all awards under this BAA. All awards are subject to the availability of funds.

III. ELIGIBILITY INFORMATION

III.1. Pre-application white papers and proposals submitted for this BAA will be considered from the following U.S. and foreign-based equivalents:

- Accredited degree-granting colleges and universities.

- Industrial/commercial basic research centers, including small businesses with a portfolio predominantly in basic research proposing a project with significant participation (minimum 30% of total effort value on the proposed project) by one or more accredited degree-granting colleges and/or universities. Note: Not eligible for Young Investigator Awards.

- Not-for-profit organizations/basic research centers with a portfolio predominantly in basic research proposing a project with significant participation (minimum 30% of total effort value on the proposed project) by one or more accredited degree-granting colleges and/or universities. 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. Note: ***Not eligible for Young Investigator Awards.***

III.2. The following entities may not participate as prime grantees for awards made under this BAA, but may act as collaborators, including as Co-PIs, and/or subawardees:

- Federal laboratories (including DoD and Department of Energy (DOE)[3] laboratories), Federal academic institutions, Federal agencies, and Federal organizations.

- 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[4].

- Foreign government-owned institutions.

- Industrial/commercial firms other than those outlined in Section III.1.

Note: DoD degree-granting academic institutions that are Federal government organizations, e.g. United States Military Academy at West Point, The Air Force Institute of Technology, etc., are eligible to submit pre-application white papers and proposals in response to the intramural Service Call issued by the DTRA Basic Research and Applied Sciences Directorate, see http://www.dtrasubmission.net and after logging in, follow the link to the 'FY11-16 Basic Research for Combating Weapons of Mass Destruction (WMD) Service Call for DoD Degree-Granting Academic Institutions'. Please note that the Service Call link will also contain the submission periods. Eligibility requirements under the Service Call are subject to change.

III.3. Cost sharing and/or matching is not required.

III.4. Other.

III.4.1. DTRA uses the Excluded Parties List System (EPLS) to exclude recipients ineligible to receive Federal awards. EPLS can be accessed online at http://epls.arnet.gov (Reference 2 CFR 1125).

III.4.2. There is no limit on the number of pre-application white papers and invited proposals that an applicant (PI/Co-PIs) may submit in response to this BAA.

- Applicants (PI/Co-PIs) may submit pre-application white papers and invited proposals to one or more topics.

- Applicants (PI/Co-PIs) may submit pre-application white papers and invited proposals to one or more periods under this BAA, regardless of a previous submission's disposition.

[3] DOE-sponsored laboratories must obtain authorization from the DOE sponsor. DTRA does not require documentation of this authorization.

[4] DOE-sponsored FFRDCs must obtain authorization from the DOE sponsor. DTRA does not require documentation of this authorization.

- Applicants (PI/Co-PIs) are **strongly** encouraged to minimize overlap in scope and level of effort if multiple projects are submitted for pre-application white papers and invited proposals. Further, individual PIs and Co-PIs are discouraged from repackaging research and submitting multiple redundant Phase I submissions in any given period of this BAA.

IV. APPLICATION AND SUBMISSION INFORMATION

IV.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 on the www.dtrasubmission.net/portal for applicant use, as noted in the text of this announcement. 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.

IV.1.1. The required application packages for the pre-application white papers are provided with this announcement. Note that each topic outlined in Section VIII has a unique application package posted with this BAA. **The application package corresponding to the topic of interest should be used for submission of pre-application white papers.**

IV.1.2. The required application packages for the invited proposals will be posted at a later date. As with the Phase I submissions, each topic outlined in Section VIII will have a unique application package**. The application package corresponding to the topic of interest should be used for submission of invited proposals.** Application packages for Phase II submissions will be posted following the notification of invitation for proposals.

IV.1.3. Example application packages for both pre-application white papers and invited proposals are included with this posting. These example packages are for demonstration purposes only and should not be used to submit applications pursuant to this BAA. These packages are clearly noted with the Competition ID of "Example" and the Competition Title of "Phase I Example Pre-Application White Paper" and "Phase II Example Application," respectively.

IV.1.4. While the review of all submissions is at the discretion of DTRA, in general, DTRA will not consider the following:

- Pre-application white papers that attempt to address multiple topics.
- Pre-application white papers that are submitted to topics from previous periods.
- Application packages and proposals for Phase II submissions that were not invited.

IV.1.5. The application packages posted to www.Grants.gov consist of the forms detailed in Table 2, which must be completed as part of the submission process. Additional files are required to be uploaded as attachments. Refer to Section IV.2.3 for more information on Phase I requirements and Section IV.2.4 for more information on Phase II requirements:

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 Form	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://www07.grants.gov/agencies/forms_instruction_information.jsp.

IV.2. Content and Form of Application Submission. Each period of 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, invited proposal submission, will be based on the evaluation results of the Phase I pre-application white paper. Pre-application white papers and invited proposals **must be** submitted electronically using Grants.gov and the corresponding application packages provided with this BAA on Grants.gov.

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.

IV.2.1. Phase I Pre-Application White Paper Submission and Content.

Each pre-application white paper must address only one of the research topics detailed in Section VIII for the relevant period. Each pre-application white paper must use the application package for the specific topic number as presented in Section VIII of this BAA.

Each Phase I application package contains the following form (Note: all other BAA guidelines must also be met to be considered a true complete package):

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.

DTRA-specific instructions for completing the SF 424 (R&R) Application for Federal Assistance are below, general application instructions can be found on 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. 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 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 1/2 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 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.

- The topic number and name should be included as a header on the white paper and in the text of the white paper.

IV.2.2. Phase II - Invited Proposal Submission and Content.

Each invited proposal must address the research topic for the corresponding Period that was the subject of the corresponding pre-application white paper, as detailed in Section VIII. Each invited proposal must use the application package for the specific topic number as presented in Section VIII of this BAA.

Each Phase II application package contains the following forms (Note: all other BAA guidelines must also be met to be considered a true complete package):

Form	Attachment	Action
SF-424 (R&R) Application for Federal Assistance Form		Enter the appropriate information in data fields
RR Budget Form	Budget Justification for entire performance period	Attach to Section K in budget period one
R&R 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	Proposal Summary/ Abstract	Attach to Block 7 Project Summary/ Abstract
	Technical Proposal	Attach to Block 8 Project Narrative
Disclosure of Lobbying Activities (SF-LLL)	N/A	N/A
Attachments Form	Attachment 1 – SOW	Upload as Attachment 1
	Attachment 2 – Quad Chart	Upload as Attachment 2

Table 4: Phase II Proposal Package Chart.

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 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.

- 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.*

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 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. DTRA encourages graduate students to attend the Annual Technical Review.

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 must include a statement discussing how the subawardee(s) was determined to

be fair and reasonable.

R&R Subaward Budget Attachment(s) Form (if applicable). Detailed cost estimates and budget justifications 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. 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 all grants and contracts through which each PI and Co-PI is currently receiving or may potentially receive financial support to be disclosed.

Research and Related Other Project Information Form.

- Block 7 – Project Summary/Abstract. The uploaded project abstract should be concise (less than 250 words) and 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.

- Block 8 – Project Narrative. 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 at www.dtrasubmission.net/portal (MS Word format).

The technical proposal must include the following components:

- Abstract.

- 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 higher

dollar amount investment and justify the scientific contribution from each investigator.

- 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.

- Performance Schedule. Provide a table of tasks and subtasks 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.

- **Attachment 1 – SOW.** The SOW does not have a page limit, but should be approximately 3-5 pages in length and appropriate for incorporation into the grant 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 at https://www.dtrasubmission.net/portal/Forms.aspx (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 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 grantee 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 parentheses 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."

- **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 at https://www.dtrasubmission.net/portal/Forms.aspx (MS PowerPoint format). A pictorial representation of the quad chart is provided herein and includes the relevant fields that must be included in the Phase II proposal submission. The inclusion of the DTRA logo is not required. The quad chart should be uploaded as "Attachment 2" of the Attachments Form.

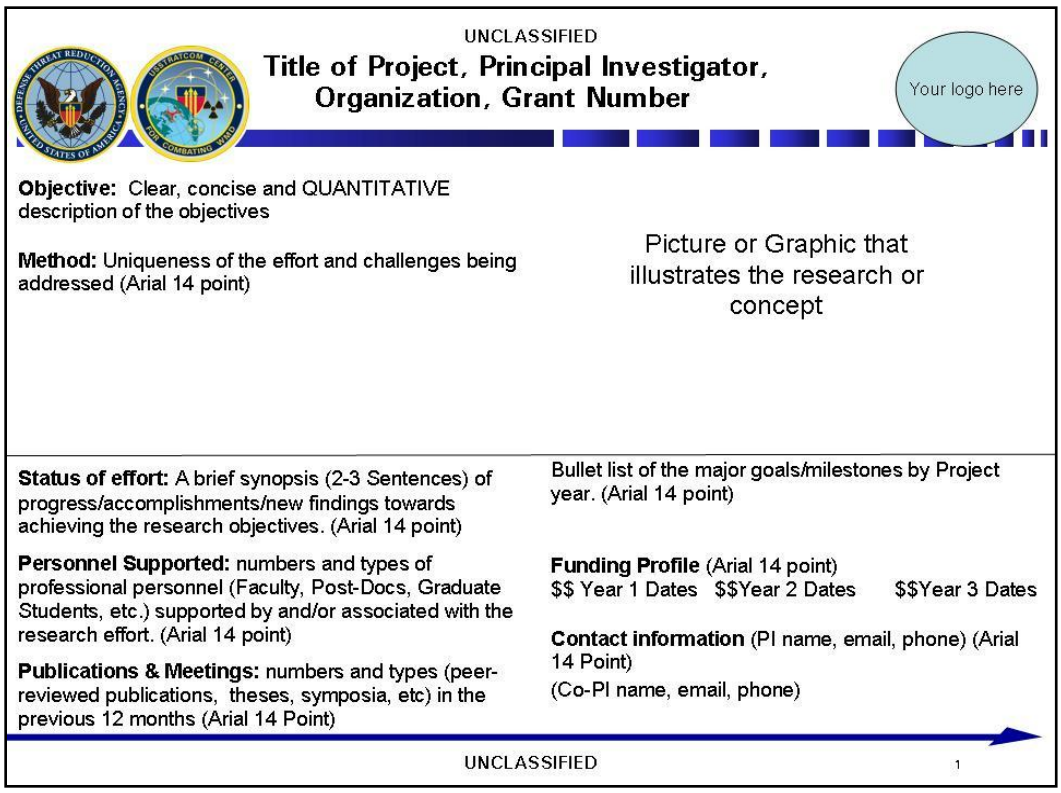


Figure 1: Sample Quad Chart.

IV.2.3. 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.

IV.2.4. All submissions must be UNCLASSIFIED.

IV.3. Submission Dates and Times.

Phase I pre-application white papers will be accepted based on periods as outlined in Table 5. A Phase II "receipt window" of 4 to 6 weeks will be provided in Table 5, however, the specific due dates for the Phase II invited proposal submissions will be provided in the letters of invitation. (The window is strictly for informational purposes only, to provide 'not prior to' and 'not later than' dates.) After the deadline date provided for a given period, the application packages will no longer be available for download from Grants.gov. Most importantly, applications received after these deadlines will only be reviewed under extremely limited circumstances, at the discretion of DTRA.

When sending electronic files, the applicant should allow for potential delays in file transfer from the originator's computer server to the Grants.gov website/computer server, as well as the delay associated with the 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 Grants.gov, and delays due to high demand encountered as the submission deadline approaches.

Applicants are responsible for submitting fully compliant pre-application white papers and invited proposals so as to be received by Grants.gov no later than the time and dates listed in Table 5 and the letter of invitation for proposals, respectively.

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 Grants.gov.

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

Additional timeline details are available to all applicants at the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal), e.g., estimated notification date for proposal invitations. Applicants are responsible for checking www.dtrasubmission.net/portal for changes and updates to the schedule.

Additional opportunities for pre-application white paper submissions with applicable topics, due dates, and application packages will be posted as amendments to this BAA. Schedules of future amendments, topic information, and due dates will not be provided and questions requesting information relevant to future amendments, schedules, and/or topics will not be answered in advance of an amendment.

Date	**Event**
1 March 2011	BAA announced on Grants.gov
Period A, Period B, Period C, and Period D are CLOSED	
Period D Grants are scheduled to be awarded October-December 2014	
Period E	
1 December 2014	Amendment to the BAA announced on Grants.gov with Period E topics, application packages, and applicable deadlines
30 January 2015	Phase I pre-application white paper receipt deadline
11:59pm EST, Not prior to 3 April 2015, and not later than 1 May 2015 *	Phase II invitation-only proposal receipt deadline
October—December 2015	Period E Grants scheduled to be awarded
Period F	
TBD	Amendment to the BAA announced on Grants.gov with Period F topics, application packages, and applicable

	deadlines
TBD	Phase I pre-application white paper receipt deadline
TBD	Phase II invitation-only proposal receipt deadline
TBD	Period F Grants scheduled to be awarded
Period G	
Period H	
Period I	
……	
Period 'n'	

Table 5: List of important dates. (This is an expanded version of Table 1, located in the Overview Information.)

If the application package and required attachments are submitted to Grants.gov after the exact time and date specified in this BAA for the pre-application white paper (Phase I) and/or the letter of invitation for the invited proposal (Phase II), the application is "late". Applications that are "late" will only be reviewed under extremely limited circumstances, at the discretion of DTRA.

If an emergency or unanticipated event interrupts normal Government processes so that proposals cannot be submitted to Grants.gov by the exact time specified in this BAA for the pre-application white paper and/or the letter of invitation for the invited proposal, and urgent Government requirements preclude amendment of the BAA closing date, the time specified for receipt of applications will be deemed to be extended to the same time of day specified in the BAA on the first work day on which normal Government processes resume.

IV.4. Intergovernmental Review. Not Applicable.

IV.5. Funding Restrictions. Indirect costs may be restricted to less than 35% of the total grant value regardless of previously negotiated rates with the cognizant agency. The 2008 DoD Appropriations Act (Public Law 110-116, Section 8115), 2009 DoD Appropriations Act (Public Law 110-329, Section 8109), and the 2010 DoD Appropriations Act (Public Law 111-118, Section 8101) applied this restriction to awards made using fiscal year 2008, 2009, and 2010 Basic Research funds. This restriction does not apply to awards made using fiscal year 2011 and later Basic Research funds, but it **may** apply to future awards.

IV.6. Other Submission Requirements.

IV.6.1. Phase I and Phase II applications must be made through www.grants.gov using the application package specific to the period/phase/topic of interest. Application packages for a *particular period* are posted with the announcement of the particular period (i.e., Period A is announced by the original posting of the BAA and the application packages are posted with it. When a new period is announced, an amendment will be published with new application packages). Applicants should take care to use the application package associated with the topic for which an application is being made.

Phase I and Phase II submissions made via any other means (e.g., hand-carried, postal service, commercial carrier, e-mail, etc.) will NOT be considered under any circumstances.

IV.6.2. Applicants should note that each organization must complete a one-time registration in order to submit its pre-application white paper(s) and application(s) through www.grants.gov. Please see the following web link on information about registering with Grants.gov: http://www07.grants.gov/applicants/applicants.jsp. If your organization is already registered in 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).

IV.6.3. All awards require certifications of compliance with Appendix A to 32 CFR 28 regarding lobbying. The full text of this certification is available at 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.

IV.6.4. 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 the 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.

IV.6.5. Pre-application white papers and invited proposals may be withdrawn by written notice received at any time before award. Withdrawals are effective upon receipt of notice by the Grants Officer via the e-mail address listed in Section VII.1.

V. APPLICATION REVIEW INFORMATION

V.1. Evaluation Criteria. The evaluation criteria to be used for review of applications are listed below. Only the first two (2) criteria will be used to evaluate pre-application white papers; all four (4) will be used to evaluate invited proposals.

1. Technical/Scientific Merit. This area addresses the technical approach and the contribution of the research to advancing the scientific body of knowledge. It evaluates what research will be performed and how it will be accomplished. Three (3) factors will be considered. The factors are listed in the order of importance.

- *Soundness of Approach.* This factor addresses whether the proposal clearly identifies and demonstrates an understanding of the scientific challenges and whether the project has a well-designed methodology, based on sound scientific principles, and how technical risks are addressed, mitigated, and managed.

- *Degree of Innovation.* This factor addresses the originality of the concept, its scientific merit, its creativity, and/or the novelty of the approach and the potential of the project to advance the scientific body of knowledge. The degree of innovation will be judged based on the innovation or originality that is appropriate to the proposed project.

- *Anticipated Scientific Impact.* This factor addresses the potential of the proposed work to provide greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts and the anticipated impact on the state of the science.

2. Responsiveness to Topic Area and Program. This area evaluates the extent to which the proposed research supports specific topic areas. It also considers the derivative benefit that may be realized by the performer and its organization through performance of the proposed research. The two (2) factors are weighted equal to each other.

    - *Responsiveness to Topic Area.* This factor addresses the responsiveness of the proposal to the objectives in the specific topic area and the contribution to the C-WMD science needs outlined in the topic.

    - *Derivative Benefit.* This factor considers training of students in science, engineering, and/or mathematics through the proposed research.

3. Program Capabilities. This area addresses key personnel, facilities, and major equipment required to accomplish the research. The two (2) factors are weighted equal to each other.

    - *Qualifications.* This factor will be scored based on the qualifications and availability of the proposed PI, co-PIs and other key personnel who are critical in achieving proposed objectives.

    - *Capabilities.* This factor considers the applicant's current or planned facilities and equipment that support achieving the proposed objectives. Capabilities evaluation will be based on the total capabilities of the assembled team that will be brought to bear as part of the proposed project.

4. Cost Realism and Reasonableness. This factor considers the adequacy and reasonableness of resources applied to each project task. This includes labor (in terms of time and mix), equipment, other direct costs, and indirect costs.

V.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 will be reviewed within the period to which it

was submitted.

Pre-application white paper (Phase I) evaluation will be based on two (2) equally weighted criteria described in Section V.1: (1) Technical/Scientific Merit and (2) Responsiveness to Topic Area and Program, which will each be scored as Green (acceptable), Yellow (acceptable with minor issues), or Red (unacceptable). The Government reserves the right to limit the number of Phase II invited proposals requested depending upon the volume of pre-application white papers submitted, the results of the Phase I evaluation, and the specific needs of the Agency.

Invited Proposal (Phase II) Evaluation will be based on the four (4) criteria described in Section V.1: Criteria (1) Technical/Scientific Merit and Criteria (2) Responsiveness to Topic Area and Program are equally weighted and are more important than Criteria (3) Program Capabilities which is more important than Criteria (4) Cost Realism and Reasonableness. All four (4) criteria receive a numerical score ranging from 1 (unacceptable) to 5 (outstanding).

Other factors that may be considered during the selection process are the possible duplication with other research currently funded by the Government, program balance across research topics, and budget limitations. 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. ***Preference will be given to university-led awards, single scope awards, and young investigator awards.***

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.

Additional details, including the due date for Phase II submissions, may be provided to applicants in the invitation email.

V.3. Technical and Administrative Support by Non-Government Personnel

It is the intent of DTRA to use non-government personnel to assist with the review and administration of submittals for this BAA.

All invited proposals will be reviewed by subject matter experts (peer reviewers) who are non-government personnel.

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. Existing DTRA contractors include but may not be limited to the following: TASC Inc. (advisory and assistance services) and their subcontractors, Suntiva Executive Consulting (contract specialist support) and their subcontractors, 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.

All individuals having access to any proprietary data must sign a non-disclosure agreement that states the 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.

All applicants to this BAA consent to the disclosure of their information under these conditions.

VI. AWARD ADMINISTRATION INFORMATION

VI.1. Award Notices.

A detailed review timeline is available to all applicants at the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal). Applicants are responsible for checking the timeline at the www.dtrasubmission.net/portal for changes and updates to the schedule.

Applicants of pre-application white papers that are not selected for invitation will be notified of the decision 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.

An invitation to submit a proposal will be extended to those applicants whose submissions were selected in Phase I. The invitation will be transmitted 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.

Applicants will be notified by DTRA of their selection/non-selection for award from the Phase II invited proposals 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. Notification of proposal selection is not an authorization to begin work.

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 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.

A debrief summary will be provided as part of all notification e-mails.

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

The 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**.

VI.2. Administrative and National Policy Requirements. The DTRA Grant Terms and Conditions may be found online at the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal). (Note: There are different versions for different recipients. As the

Terms and Conditions are updated, they will be posted on the 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 IV.6.3 for the certification(s) required at the time of submission.

SAM Registration. DTRA uses the SAM to exclude recipients ineligible to receive Federal awards. SAM can be accessed online at http://sam.gov (Reference 2 CFR 25.200).

- Be registered in the SAM prior to submitting an application (or plan);
- Maintain an active SAM registration with current information at all times during which it has an active Federal award or an application (or plan) under consideration by an agency; and
- Provide its DUNS number in each application (or plan) it submits to the agency.

VI.2.1. Protection of Human Subjects. It is not anticipated that human subjects would be involved in basic research. If the proposed research does involve human subjects or materials, applicants are asked to justify the use of human subjects and to address the following issues: outline the human use, to include the source of the human subjects or materials involved in the research. Further information may be required if the proposal is successful. The Common Federal Policy for the Protection of Human Subjects, codified by the Department of Health and Human Services at 45 CFR 46 and implemented by the Department of Defense at 32 CFR 219.

The recipient shall adhere to DTRA local clause 252.223-9002. The full text of this clause is as follows:

All research under this grant involving human subjects must be conducted in accordance with 32 CFR 219, 10 USC 980, and DoDD 3216.02, as well as other applicable federal and state regulations. Grantees 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 USC 980). DTRA Directive 3216.01 establishes the DTRA Human Subjects Protection Program, sets forth the policies, defines the applicable terms, and delineates 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 Defense Threat Reduction Agency's Research Oversight Board (ROB) has reviewed and approved the proposed protocol. Grantees 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 Institutional Review Board (IRB) to include consent forms for any planned research using human subjects to the DTRA ROB for its review through the Grants Officer's representative (if assigned) or the Grants Officer. The ROB review is separate from, and in addition to, local IRB review.

Written approval to begin research or subcontract for the use of human subjects under the proposed protocol will be provided in writing from the DTRA ROB, through the Grants Officer. A copy of this approval shall be maintained by both the Grantee and the government. 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 PI
- 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
- changes in perceived or measured risks or benefits to volunteers that require changes to the study

Research pursuant to such modifications or amendments shall 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. ROB review and approval is required annually. The Grantee or subcontractor must provide documentation of continued IRB review of protocols for ROB review and approval in accordance with these Terms and Conditions. Research must not continue without renewed ROB approval unless necessary to eliminate apparent and immediate hazards to the subject(s).

Non-compliance with any provision of this clause may result in withholding of payments under the grant pursuant to the grant's payments clause(s) and/or grant termination pursuant to the grant'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.

VI.2.2. Animal Use. It is not anticipated that animal use would be involved in basic research. If the proposed research does involve animal use, however, applicants are asked to justify the use of animals and to address the following issues: any proposals that include animal studies or animal work must submit 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. Further information may be required if the proposal is successful.

The recipient shall adhere to DTRA local clause 252.235-9002 – Animal Use (Jul 2010). The full text of this clause is as follows:

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) are planned. This information, if applicable, must be included in the project narrative. 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 can be found on the ACURO website (https://mrmc-www.army.mil/index.cfm?pageid=Research_ Protections.acuro&rn=1). Allow 2 to 4 months for regulatory review and approval processes for animal studies. Offerors are to build this review time into their project schedules.

DoD Directive 3216.1, dated April 17, 1995, provides policy and requirements for the use of animals in DoD-funded research along with Army Regulation 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 Directive 3216.1 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.

VI.2.3. 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: www.access.gpo.gov/nara/cfr/waisidx_99/32cfr626_99.html for a copy of 32 CFR 626.18, Biological Defense Safety Program.)

VI.2.4. 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://oba.od.nih.gov/biosecurity/news_events_oba.html#NSABB]. 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.

VI.2.5. Military Recruiting. This is to notify potential applicants that each grant awarded 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 cooperative agreements, 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://ecfr.gpoaccess.gov/. 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 grant awarded 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.

VI.2.6. 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).

VI.2.7. It is the policy of the DoD that the publication of products of basic research will remain unrestricted to the maximum extent possible. Pursuant to DoD policy, awardees are strongly encouraged to publish the results or findings of their research in peer-reviewed journals.

VI.2.8. 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)).

VI.2.9. 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).

VI.3. Reporting. General requirements are provided below; however, each grantee should check the award agreement and its terms and conditions to determine the requirements for that specific award.

Annual Research Performance Progress Report(s): Annual progress reports will be due no later than 1 July of each year. Awards effective after 31 January will not require a progress report until 1 July of the following year.

Final Technical Reports: A comprehensive final technical report is required at the end of an effort, due on the date specified in the terms and conditions of the grant document. The purpose of the final report is to document the results of the effort. 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).

The Federal Financial Report SF425 is due quarterly, no later than 30 days after the end of the reporting period. Reporting periods are as follows: 1 January – 31 March, 1 April – 30 June, 1 July – 30 September, and 1 October – 31 December. Final reports shall be submitted no later than 90 days after the project or grant period end date.

All reports shall be submitted to the Administrative Office identified in the Research Grant and as outlined in the Terms and Conditions of the award document.

VI.4. After-the-Award Requirements. 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 32.61 – 63 (For-Profit Organizations).

VII. AGENCY CONTACTS

VII.1. All administrative and programmatic correspondence should be directed to: HDTRA1-BRCWMD-A@dtra.mil.

Every effort will be made to provide a timely response to all inquiries; however, e-mails may not receive a response. Attachments will not be reviewed.

VII.2. Specific technical correspondence regarding the thrust areas as well as the topics may be directed to the following e-mail addresses:

Thrust Area 1: BRCWMD-TA1@dtra.mil

Thrust Area 2: BRCWMD-TA2@dtra.mil

Thrust Area 3: BRCWMD-TA3@dtra.mil

Thrust Area 3 (CB): BRCWMD-TA3-CB@dtra.mil

Thrust Area 4: BRCWMD-TA4@dtra.mil

Thrust Area 5: BRCWMD-TA5@dtra.mil

Please note that technical correspondence e-mails may or may not be reviewed and responded to; **attachments will not be reviewed**.

VII.2.1. Dialogue that assists the applicants in developing better pre-application white papers and invited proposals is encouraged.

VII.2.2. Questions regarding debriefing summaries for pre-application white papers that are invited to full proposals are encouraged.

VII.2.3. Requests to reconsider pre-application white papers and/or proposals, requests for additional information beyond the debriefing summaries for non-invites/non-selections, and rebuttals to the debriefing summary (e.g., additional data, further explanation, etc.) WILL NOT be considered under any circumstances.

VIII. OTHER INFORMATION – TOPICS

VIII.1. Topics for future periods with corresponding pre-application white paper due dates will be published via amendments to this BAA. 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.

VIII.2. This BAA, in addition to any amendments issued in conjunction with this BAA, will be posted to the Grants.gov Grant Opportunities Website (www.Grants.gov) and for informational purposes to the DTRA Basic and Fundamental Research Portal (www.dtrasubmission.net/portal).

Note: The DTRA Basic and Fundamental Research Portal (www.dtrasubmission.net/portal) is available to all applicants. Information available at the portal includes, but is not limited to, the following: a detailed timeline for this BAA, templates that may be used when preparing pre-application white papers and invited proposals, sign-in for applicants to view the status of their submission(s), and a list of previous awards made by the Basic Research for C-WMD Program.

DTRA Basic Research Needs

PerE-Topic 1: Methodologies for Autonomous Radiological and Multi-mode Information Collection (Thrust Area 1)

Average Award Amounts for PerE-Topic 1:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 1:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: Sensing of short range radiological signatures in limited access environments is a difficult problem. Because most direct radiological signatures can often only be detected at close range (< 100 m), mechanisms to employ autonomous platforms permitting close, discrete information collection is desirable. Further, the ability for these platforms to successfully select between a range of detection algorithms and methods based on information gained from secondary signatures also likely to be present (such as magnetic, optical, infrared, seismic, acoustic, or others) is also potentially necessary. Rapid ability to choose among these disparate methods may require automatic action in a disturbed and quickly changing environment.

Impact: Autonomous platforms capable of using minimal data exchange between each other and/or support from reachback or other command resources will reduce the limitations that may be introduced by dependence on human reaction times. Furthermore, such platforms will be able to successfully navigate a wide range of terrain either on their own or via collaboration with a variety of heterogeneous land/air platforms. Detection systems would also be enhanced by capabilities to collect from challenging environments and return samples to staging points. Additionally, the ability to identify and deploy sensors as part of long dwell (mission dependent, but may extend to months or longer) "leave behind" capability improves persistent surveillance.

Objective: The focus of this topic is on identification of the key scientific obstacles to the deployment of autonomous counter-WMD search assets especially useful for detection of radiological signatures. This topic investigates the identification of approaches towards this kind of autonomous search capability, and does not focus on the development of hardware for platform mobility or sensors. Proposals that engage government laboratory institutions are also encouraged.

Research areas may include but are not limited to the following areas:

- The investigation of appropriate autonomous search algorithms, communication-minimal cooperation schemes, and detection algorithm/method decision logic supporting the employment of multiple autonomous search platforms against a radioactive source located in a large (~km^2) complex area that may contain obstacles, including shielding structures

- The exploration of multi-mode, one mode being a radiological signature, detection summary reporting methods suitable for employment over long latency small bandwidth wireless communications links
- The identification of methods to deploy long dwell detectors from these platforms as needed, and the identification of methods (i.e. hierarchically distributed sensors) for such platforms to autonomously choose deployment locations for these long dwell detectors based on radiological (i.e. varying signal to noise environments), or operational constraints
- The investigation of autonomously assigning roles to assets, self-organizing techniques, and the optimization of resources for radiological signature sensing

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PerE-YIP-Topic 1: Methodologies for Autonomous Radiological and Multi-mode Information Collection (Thrust Area 1)

Average Award Amounts for PerE-YIP-Topic 1 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 1.

PerE-Topic 2: Advancing Nuclear Forensic Methods for Collecting and Analyzing Post-Detonation Debris (Thrust Area 1)

Average Award Amounts for PerE-Topic 2:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 2:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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 ways to enable accurate post-detonation analysis of debris from a nuclear event on a short time scale. The DoD provides the capability to collect and analyze post-detonation debris. DTRA is responsible for research and development that will enable this post-detonation forensics. The current methodology includes a radiochemical assay that requires time to obtain statistically accurate results. The advancement of analytical techniques could lead to the ability to accurately analyze debris on time scales shorter than this current methodology. Of interest are innovations that identify and quantify elemental and isotopic constituents of a fresh radioactive fallout debris sample. Of particular interest are accurate and timely measurements of major, minor, and trace constituents, including actinide species, fission products, and activation species. Ideally, novel methodologies to perform these measurements would be field-adaptable and non-destructive, allowing for additional confirmation analysis on the same sample. Furthermore, improvement within the capability of sample collection is needed, as well as improvements in predictive modeling of the quality of airborne debris collection; novel methods are sought which have the potential for greater robustness under a wider variety of adverse conditions. Combining novel collection and analysis techniques is of interest

where the analysis provides either identification or quantitative isotopic composition of the debris. Other areas of interest include understanding phenomenology that govern novel analysis methodologies, methodologies for compiling, assessing, and interpreting large sets of data, as well as understanding the treatment of data uncertainties. Disciplines which may advance the science for post-detonation nuclear forensics include but are not limited to chemistry, nuclear physics and engineering, materials science, instrument development, mathematics and statistics, computer science and modeling and simulation.

Impact: The development of advanced post detonation forensics addresses DTRA's counter-WMD need to enable: prevention of future detonations, identification of those responsible, and improvement in response and recovery efforts. Such research has the potential to lead to a field-deployable system with a real-time analysis capability.

Objective: This topic explores novel methods and advancements in the ability to collect samples of material, analyze radioactive debris, and identify signatures from debris analysis in a post-detonation environment. Specific interests include the investigation of non-destructive analytical techniques, fundamental phenomenology of analytical measurements, and innovative data-set handling. Laser-Induced Breakdown Spectroscopy (LIBS) and LIBS-like technologies are not sought at this time and will not be considered. Proposals that engage government laboratory institutions are permitted and encouraged.

Research areas may include but are not limited to the following areas:

- Novel methods that enable rapid and cost-effective isotopic identification and measurement after a nuclear detonation
- Field-adaptable analytical techniques
    - Non-destructive methodologies are preferred
- Exploration of waterborne sample analysis
- Investigation of historic waterborne sample data and possible correlation to historic particle or gaseous sample forensics conclusions for the same events
- Investigations to improve databases of physical constants and their uncertainties
    - Constants such as cross sections, decay branching ratios, or nuclear energy levels relevant to nuclear forensic analysis
- Investigation of techniques with the potential to eliminate the need for time-consuming separative radiochemistry on a gross vs. net timeline
    - Techniques that reduce the overall timeline are preferred over techniques that have a short timeline but require multiple measurements, lengthy calibration procedures, etc.
- Techniques or methodologies for repetitively validating and verifying measurements made on samples that have components inherently disappearing and changing with time
- Novel methods to create realistic debris standards for collection and analysis validation
- Mathematical and statistical treatment methods of large, complex data sets relevant to radiological analyses
    - Exploration of methods with the potential to enable remote characterization and quantification of airborne debris
- New methods for targeted sample collection after a nuclear event
    - Novel methodologies for determination of collection locations in a post-detonation environment
    - Combined airborne and ground collection and analysis methods
    - Exploration of combined meteorological models with nuclear fallout models
    - Novel tool for quality prediction of airborne debris collection
- Advanced methods of sample pre-concentration for higher signal output

PerE-YIP-Topic 2: Advancing Nuclear Forensic Methods for Collecting and Analyzing Post-Detonation Debris (Thrust Area 1)

Average Award Amounts for PerE-YIP-Topic 2 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 2.

PerE-Topic 3: Development of Models for the Time Evolution of Realistic Multilayered Networks in Response to Large-Scale Damage (Thrust Area 2)

Average Award Amounts for PerE-Topic 3:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 3:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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 dependence of military and national capabilities on increasingly complex and layered networks requires the development of models which can provide realistic representations of these networks, in particular to the effects of large-scale damage resulting from a WMD attack. The development of technologies which can provide real-time data on large multilayered networks allows for modeling of real networks in order to simulate and study WMD effects on real networks. The modeling of these effects is not limited to the initial damage but requires the modeling of the propagation of this damage through and across the multiple layers of the networks. A particular difficulty arises in modeling the large size of realistic networks and the propagation of effects across multiple networks and network layers.

Impact: The results of this research are intended to produce methods and models capable of simulating the time evolution of effects of large-scale damage across multiple layers of large communication, control, and power networks. These models can then be used to analyze the immediate and long-term damage and recovery of real networks in response to the large-scale damage of WMD effects. This analysis can be used for command and control evaluation involving tasks such as identifying critical points within a network or development of methods to prevent or mitigate the propagation of damage throughout a network.

Objective: The objective of this research is to develop the mathematical underpinnings suitable for network models which can provide accurate representations of real networks over time in response to large-scale damage. The mathematical representations should look at the evolution and propagation of damage over time and across multiple network layers. This should include multiple time scales of short-term damage propagation and long-term restoration and recovery. In order to verify and validate the functionality of the network models to produce realistic simulation of large networks, real data should be used. This includes use of the data to verify

that models can provide accurate representations of real historic events and validate that they can provide representations of real world networks in response to large-scale WMD damage.

Suggested model development could include these features:

- Multiple large (greater than 10,000 nodes) multilayer networks (communication, control, and power) and their interactions, not just on a single layer
- Use of realistic, large datasets to produce results
- Validity and usefulness of any assumptions within the model of real networks should be clearly explained
- Explain how the model deals with uncertainties in the data
- Cover the time evolution of the network across multiple time scales in response to large-scale damage. This would include transient rapid behavior on the order of seconds to outages that may persist for hours.
- Preliminary verification and validation schemes
- Reflect analysis of real failure events and nominal data from many different interdependent systems, including investigation of complex cases of multiple failure modes
- Identify key interconnected system features which lead to fragility or robustness, perhaps starting with single point failures then leading to multi-point failures
- Identify and quantify methods to improve robustness of critical infrastructures
- Development of innovative mathematical tools
- Model should reflect an understanding of the spatial and temporal distribution of damage
- Identification of minimal data sets required for meaningful decision analysis and estimates of associated uncertainties, for pre-event protection as well as post-event recovery
- Identification of data which, if public, would enable effective WMD attacks or better protection
- Quantification of impacts of hidden failures of network components on overall network responses
- Assure awareness of current worldwide literature on network effects, societal impacts, and robustness

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PerE-YIP-Topic 3: Development of Models for the Time Evolution of Realistic Multilayered Networks in Response to Large-Scale Damage (Thrust Area 2)

Average Award Amounts for PerE-YIP-Topic 3 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 3.

PerE-Topic 4: Machine Learning Methods for Network Analysis (Thrust Area 2)

Average Award Amounts for PerE-Topic 4:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 4:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: WMD-related activity is difficult to detect because evidence tends to be low observable and ambiguous. Combinations of evidence tend to be critical to detection of WMD-related activity. Networks relating observations and representing interactions provide additional evidence that can demonstrate patterns to expose WMD-related activity long before it would be evident by other means.

DTRA's data has structure not present in many applications.

- Much of the data available to us is rich, heterogeneous, and interlinked.
- Information about people, events, places, and interactions, whether extracted from text, communications, transactions, or a variety of sensor networks, often requires reasoning about the network (the entities and relationships) while taking into account noise, uncertainty, and ambiguity in the observational data.
- In social networks, links and nodes may be intentionally obscured or missed, not only making inference more difficult but also altering the underlying probabilistic model.
- The model can also change over time as the social network in question changes.
- Even constructing the network, by integrating the multiple data sources, is a challenging problem that requires inferring the correspondence between nodes and entities and the mappings between observational relationships and linguistic links.
- Impact of cultural factors (cultural practices and social norms) can influence the social network statistics and must be individualized in the learning and inference process.

Impact: Advanced network algorithms that can incorporate the above issues will enable DTRA to add additional evidence in detecting and analyzing low footprint activity involved in the development or acquisition of WMD. This will be particularly important in the many instances where there is no direct evidence and only patterns of activity are observed.

Objective: The objective of this program is to advance the foundational elements of network analysis upon which algorithms, which can address problems of high priority to combating WMD threats, can be developed. These capabilities should have a large and broad impact.

Key motivating problems are node characterization, link prediction, and general inference of network phenomena (e.g. detect latent causes), all of which require probabilistic reasoning. The thrust of this topic is the incorporation of structured leaning and related forms of probabilistic reasoning to address the above network problems. Methods that also have broader applicability to secondary problems will be preferred. Examples of second tier problems include anomaly detection, overlapping community detection, node change prediction, temporal analysis, and prediction of how networks adapt to external induced changes.

The primary problems are driven by the problem of detection. Methods explicitly not of interest under this research program include social problems such as exerting influence within the network or ascertaining the power structures within the network.

The core of the proposed effort should address probabilistic representation, learning, and inference methods needed to represent uncertainty and reason collectively across network data. Desirable extensions of these methods are the ability to:

- Exploit novel representations schemes (examples include: embedded or hyperbolic geometry, network decomposition, network grammars, new matrices, and spectral graph theory)
- Develop faster versions of existing methods that still maintain the integrity of the result
- Represent, analyze, and reason on hypergraphs (i.e. multipartite graphs)
- Capture multiple node and edge types, each potentially with attribute information including text, image and other multimedia data
- Capture socio-behavioral interactions, taking into account temporal and spatial information where applicable, causal information where available, and discover latent structure
- Develop inference algorithms that are able to infer missing values, discover anomalies, and make predictions about unknowns at the node and link level, not just about the aggregate properties of the network

Attention should be given to computational speed and scaling. The anticipated order of computation should be discussed in the proposal. Empirical validation should also be part of the proposer's plan. The proposals should briefly comment on what data will be used or how data will be found. Data need not relate to WMD but ideally would have comparable network structure and behavior. It is not essential to work on extremely large networks, but the concepts should be testable on a network on the order of at least 10,000 nodes. Comments on the scalability both in speed and memory should be included.

Proposals should: make clear what distinguishes the approach from other possible approaches and provide the reason as to why the approach was chosen over other potential approaches; and identify risks and considerations that would mitigate risks. Failure to consider risks may be taken as an indication of a failure to anticipate them. The proposals should also lay out a case as to why there is a reasonable expectation of success and detail what results might be expected. Proposals involving collaboration between different key experts or institutions should provide an indication of level of effort among the participants.

PerE-YIP-Topic 4: Machine Learning Methods for Network Analysis (Thrust Area 2)

Average Award Amounts for PerE-YIP-Topic 4 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 4.

PerE-Topic 5: Semantic Representation (Thrust Area 2)

Average Award Amounts for PerE-Topic 5:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 5:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.

- 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 currently a failure in DTRA's ability to extract evidence of preparation of development of WMD and WMD attacks. Sixty percent of sentence-level events are missed or misclassified. However, post hoc analysis indicates that evidence of WMD incidents was usually manifest in reports and other communications available at the time. This evidence for instances of WMD-related activities is buried in a sea of background data that is so vast that advanced machine reading capabilities are required. Often the individual pieces of WMD evidence are low observable and ambiguous. It is only when multiple pieces of evidence are collectively assessed, that detection can be made. This requires a high probability of detecting each piece of evidence, as small chances of failure compound exponentially when multiplied across the large quantity of necessary data.

WMD-related evidence takes the form of extracted sentence-level events. These events have a predicate-argument structure that provides the basis of meaning for a sentence. While these events are contained within sentences, there are limitations to understanding the events on the semantic level. Identifying semantic indicators such as verb sub-categorization, meaning components, selectional preferences, and semantic roles are poorly developed to varying degrees, and in some cases poorly understood. For example, ambiguous word senses and semantic roles are difficult to label. These limitations translate to the current limited ability to detect WMD-related activity.

Operational demands may occur in data scarce environments, thus data must be deeply analyzed with detection rates in a computationally demanding environment that has a high flow of information. The information is expressed in poor grammar and using diverse and irregular language, which increases the demands on the representations used. Discourse analysis to find informational relationships between sentences is insufficient. Research in the commercial sector has mainly focused on maximizing precision, not recall. A primary driver to properly analyze events is to convert text to meaning, which depends on the semantic tools available (WordNet, VerbNet, FrameNet, etc). Methods must automatically find semantic representations for words in their textural context.

Impact: This research will advance the theoretical understanding and methods necessary to improve existing natural language processing. Specifically, it will enable a new class of algorithms that will allow DTRA to move from the term level to the semantic level. Fundamentally it will enhance event analysis from its current unacceptable failure level of 60%. Improving this means improving detection of evidence relevant to WMD. Beyond text analysis, progress in representational learning will impact DTRA's pattern recognition systems across all types of data. In a broader sense, this research will enable many operational requirements that use text, such as information retrieval, question and answering systems, reasoning systems, machine translation and the semantic web, and other semantically encoded applications.

Objective: To develop improved methods to determine and incorporate semantic information to accurately analyze events. Proposed research may be an extension of existing approaches, but it could also develop innovative methods that mirror linguistic structures in new ways. The main thrust of this topic is to bring distributional semantic analysis on the meaning component level. The research should ultimately support areas such as:

- *Representation*: Develop semantic representation schemes to unambiguously express meaning. For "terms", example representations could include structures and components. For "relative meaning", example representations could include location or weights within some semantic space.
- *Identification*: Develop automatic processing of corpora to identify both lexical semantics and semantic relationships involved in predicate-argument or some alternative to represent semantic structure for sentences.

- *Interpretation*: Develop automatic processes to translate words (and potentially phrases or sentences) to a form that provides semantic characterization. The process should take into account contextual cues.

Research areas should be in one or both of the following two areas:

Research Area 1: *Automatic determination of semantic components across multiple languages*. Distributional semantics works at a finer level, but does not use an explicit representation of semantic components. Only a small number of words have been decomposed into components. The different languages often vary in meaning at the word level, but are consistent at the semantic component level. This is especially true for unrelated languages. These variations can provide a means to automatic determination of semantic components. Proposals should identify a small set of unrelated languages (minimum of three) to be used to find semantic components. Components should be at broad applicable concepts not nuances between one or two terms. Examples are orientation, topology, force dynamics, possession, causality, and various state changes. Inspiration for this topic comes from previous work by Beth Levin and Leonard Talmy in semantic components.

Two issues should be addressed specifically in this research area. First, many methods discover semantic information that is syntagmatic in nature; whereas often the more valuable information is paradigmatic. Can the proposed method find paradigmatic relations or alternative forms of meaning to syntagmatic relations? Moreover, how can the representation reflect meaningful semantic structures in contrast to mere statistical correlations that have no linguistic basis? Second, distributed semantics exhibit a news bias, i.e., finding information that is reported, but missing common real world information that is typically known. Can the proposed method mitigate or address this issue?

Research Area 2: *Development of distributed semantic methods.* Development of more effective distributed semantic methods or better ways of working with existing distributed semantic methods. Many of these methods (e.g. deep learning) lack transparency and interpretability. Of high interest are methods that improve these attributes or alternative methods that exhibit these attributes. Development could include insights from comparison of methods, improving performance, and understanding best practices of using such methods. The model used to encode the information (e.g. vector space, hierarchy, network, etc.) should be justified. There are a number of starting points for the investigation. Ideally, a proposal might include multiple research areas. These proposals could focus on:

- Advances in distributional analysis representations of input or within the algorithm. This could include input in a syntactic form, semantic features (e.g. Jackendoff's conceptual functions), selectional preferences, or semantic components. Methods that capitalize on a semantic representation such as semantic components within the method are also of particular interest.
- Methods that can better utilize textual evidence information for input. Currently textual evidence information is not in co-occurrences, but it is in nonlocal features that might span one or multiple sentences involving technical key words such as the names of special equipment, materials, or organisms.
- Methods that use underlying latent information or incorporate background knowledge since WMD-related data tends to be sparse.
- Methods to encode and fuse contextual or syntactic information with semantic information.
- Innovative methods to map or transform the data to an alternate form. For example, superior ways to map words to data structures (e.g. vectors, networks, feature structures, hypergraphs, hybrid approaches, etc.).
- Ways to augment semantic distributional analysis with other data analysis methods such as dimensionality reduction, e.g. compressed sensing theory, manifold learning, hashing, etc.

Later in the investigations, areas such as the following may be addressed (for Research Area 1 or 2):

- Development or improvement of contributing components that enable distributional semantic methods such as similarity measures.
- Incorporation of real world and linguistic knowledge.
- Hybrid discrete and distributional processing that exploit the strengths of each. Consideration will be given to approaches that have application to verb sub-categorization, parsing, word sense disambiguation, semantic role labeling, identification of selectional preferences, or other forms of semantic representation of sentences. Demonstration of applicability might be given in later phases of the research.
- How to get composable representation of meaning without parametric burden of current methods such as representing combination of words and phrases vector as tensors.

Proposals should: specify both the method to infer representation and also the representational basis (e.g. vector space, network, hierarchical, word clustering or other similarity metrics); make clear what distinguishes the approach from other possible approaches and provide the reason as to why the approach was chosen over other potential approaches; and identify risks and considerations that would mitigate risks. Failure to consider risks may be taken as an indication of a failure to anticipate them. The proposals should also lay out a case as to why there is a reasonable expectation of success and detail what results might be expected. Proposals involving collaboration between different key experts or institutions should provide an indication of level of effort among the participants.

PerE-YIP-Topic 5: Semantic Representation (Thrust Area 2)

Average Award Amounts for PerE-YIP-Topic 5 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 5.

PerE-Topic 6: Model Framework for Societal Responses to Nuclear Events (Thrust Area 2)

Average Award Amounts for PerE-Topic 6:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 6:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: Global defense postures require greater specificity of higher order WMD effects on population dynamics. Such higher order effects may include complex cascading behavior between various social systems/networks that have traditionally been too complex to easily describe. However, current planning is largely devoid of WMD effects considerations beyond direct physical damage and contamination. The current

body of theory for WMD damage largely focuses on direct physical damage, and less so on complex societal impact. Increased fidelity of additional societal consequences from post WMD scenarios is required to allow decreased recovery time. Moreover, increasing globalization, with concomitant industrial and political linkages, exacerbate the cascading effects of a WMD event beyond borders and direct physical damage. Recent studies and exercises indicate that models require a more complete understanding of societal influence in analyzing the consequences of execution when WMD events occur; and that efforts to specifically model population behaviors in response to WMD events either rely on natural disaster data[1], or assume uniform human behavior responses[2]. Analogous to behavioral differences by disaster type, representativeness of behavioral dynamics to a sudden WMD event cannot be assumed.

Underscored by the dearth of holistic current research on socio-cultural factors within the context of a WMD event, DTRA's investment is requisite to improving the present-day understanding of higher order effects on human behavior across distinct cultural and regional characteristics. To be relevant to DTRA, WMD higher order effects modeling must become more dynamic by taking into account the behaviors of the affected populace and the social impacts in the context of the preexisting conditions in a region. Demographic factors such as population density, degree of urbanization, age, gender, sex, ethnicity, culture, education, previous military training, etc. can yield nuanced differences in the non-directed (i.e., no government entity is directing the population where to relocate) migration patterns. Because coordinated plans beyond the regional level have been shown to expedite a region's ability to recover from high-impact events and minimize global cascading effects, it is important to both map the socio-cultural and geo-political terrain by region, as well as incorporate the inter-regional human ties and infrastructural interdependencies, with concomitant consideration of situational preconditions or existing stressors.

Impact: After a WMD event, decision makers need to know how the affected population can effectively respond and recover. Delivering information of this nature is critical for: directing troop movement to avoid congested areas which would hinder mission success; directing appropriate types and levels of aid to the incumbent, displaced and migrating population; and engaging the correct local government officials and agencies to manage humanitarian efforts. The primary impact of this research will be the future development of new capabilities for national decision support. A framework to capture the affected population's behavioral dynamics, coupled with their underlying regional socio-cultural and geo-political conditions, will lend greater fidelity to decision making, as well as expand the constrained strategic planning tool-kits in use today. A successful multi-dimensional model will need to overcome the significant challenge to integrate the various layers to be represented in the model.

Objective: Research conducted under this topic will develop a mathematical framework to predict non-static societal response following a WMD event. Proposals must identify relevant data sources that will be used. Only proposals that develop mathematical frameworks will be considered.

Research proposals should cover one or more of the following:

- Develop a mathematical framework to model non-directed, local/regional migration for various segments of a society reacting to a WMD event
- Determine which societal, political, environmental, economic, military, etc. factors and preconditions are relevant to the developed mathematical framework and their respective sensitivities
- Methods to incorporate information from local infrastructure and social networks into comprehensive response models
- Develop computational algorithms and methods that allow for a variety of WMD scenarios, model extensions, and validation
- A thorough description of the proposed data sources required to make the models tractable

[1] Kanno, Taro, Tatsuya Shimizu, and Kazuo Furuta. "Modeling and simulation of residents' response in nuclear disaster." *Cognition, Technology & Work* 8.2 (2006): 124-136.

[2] Parikh, Nidhi, et al. "Modeling human behavior in the aftermath of a hypothetical improvised nuclear detonation." *Proceedings of the 2013 international conference on Autonomous agents and multi-agent systems.* International Foundation for Autonomous Agents and Multiagent Systems, 2013.

PerE-YIP-Topic 6: Model Framework for Societal Responses to Nuclear Events (Thrust Area 2)

Average Award Amounts for PerE-YIP-Topic 6 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 6.

PerE-Topic 7: Epigenetics of Response to Radiation (Thrust Area 3)

Average Award Amounts for PerE-Topic 7:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 7:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: Studying the effects of ionizing radiation on biological systems relates to the DTRA mission for mitigating the consequences of WMD, particularly in terms of (#1) providing c-WMD situational awareness and preventing proliferation of WMD, and (#2) protecting the warfighter from deleterious effects from ionizing radiation (IR) exposure. In terms of (#1) providing c-WMD situational awareness, the warfighter may encounter environments where the exact nature and extent of radiological contamination is unknown. Naturally occurring indicator species, or bioindicators, may act as an orthogonal means of identifying radiological contamination if they undergo a readily observable and specific stress-induced response to IR and/or absorption/adsorption of radionuclides[1-3]. Studying how epigenetic processes influence phenotypic plasticity may lead to improved identification or design of radionuclide bioindicator species. In terms of (#2) protecting the warfighter from deleterious effects of IR exposure, there is a growing body of evidence that some diseases are dominated by epigenetic processes[4-5]. Therefore a better understanding of underlying epigenetic processes may lead to the development of novel and efficacious pre and post treatments for IR exposure and can aid in establishing reasonable exposure limits. Several mechanisms have been shown to play a role in IR-induced changes including DNA damage as well as epigenetic-associated mechanisms such as DNA methylation, modification to histones, and RNA-associated silencing[6-7]. While there has been a substantial amount of research on IR-induced DNA damage, a systems biology (holistic) understanding of the role epigenetic mechanisms play in phenotypic plasticity is still lacking. Additionally, the relative contribution genetic versus epigenetic processes make to induction of phenotypic plasticity in response to IR exposure is not known.

Impact: Research conducted under this topic will lead to the identification and holistic understanding of IR-stress induced mechanisms and pathways that lead to phenotypic changes in bioindicator species. This research may lead to improved identification or design of radionuclide bioindicator species as well as protection of the warfighter from the deleterious effects from IR. Additionally this research may lead to an orthogonal means for early warning of environmental contamination with radionuclear materials as well as a means to detect undeclared nuclear activities. The proposed research is responsive to the Department of Defense Strategy for Countering Weapons of Mass Destruction (2006) with regard to minimizing WMD effects to sustain military operations in a "WMD environment[8]."

Objective: The proposed research seeks to identify and characterize epigenetic mechanisms of IR stress-induced phenotypic changes in previously characterized bioindicator species. Proposals using genetically modified organisms or cancer studies will not be considered. Of particular interest to DTRA are low-level radiological environments where exposures between 0.1-1 Gray to the warfighter may occur. Ideal bioindicators will have the following conditions met:

- There is a reasonable amount of biological information already available on them that can guide development of testable hypotheses regarding use as environmental indicators.
- They are amenable to future research in order to obtain missing or imprecise data.
- They are either ubiquitously distributed or, if indigenous, present in some abundance in particular ecosystems of interest.
- Their geographical ranges are limited and/or well-defined.
- They are likely to be exposed to radiation as a result of their own natural ecology (e.g., feeding habits).
- Their life cycles are likely to be of some relevance for evaluating radiological contamination events from a temporal perspective.

Research areas may include but are not limited to the following:

- Development and execution of systematic approaches to determine the relative extents to which genetic versus epigenetic processes are responsible for morphological/physiological changes.
- Theoretical development and testing of holistic temporal models of genetic and epigenetic processes involved in phenotypic plasticity in response to IR.
- Identification and characterization of protein receptors involved in “sensing” IR and their connection with epigenetic reprogramming.
- Determination of whether epigenetic mechanisms resulting in phenotypic changes may be extrapolated to other species.

[1] Bräutigam, Katharina, et al. "Epigenetic regulation of adaptive responses of forest tree species to the environment." *Ecology and evolution* 3.2 (2013): 399-415.

[2] Hiyama, Atsuki, Wataru Taira, and Joji M. Otaki. "Color-pattern evolution in response to environmental stress in butterflies." *Epigenomics and Epigenetics* 3 (2012): 15.

[3] Møller, Anders Pape, and Timothy A. Mousseau. "Efficiency of bio-indicators for low-level radiation under field conditions." *Ecological Indicators* 11.2 (2011): 424-430.

[4] Egger, Gerda, et al. "Epigenetics in human disease and prospects for epigenetic therapy." *Nature* 429.6990 (2004): 457-463.

[5] Feinberg, Andrew P. "Phenotypic plasticity and the epigenetics of human disease." *Nature* 447.7143 (2007): 433-440.

[6] Geras' kin, S., T. Evseeva, and A. Oudalova. "Effects of long-term chronic exposure to radionuclides in plant populations." *Journal of environmental radioactivity* 121 (2013): 22-32.

[7] Kovalchuk, Olga. "Epigenetic Effects of Ionizing Radiation." *Environmental Epigenomics in Health and Disease*. Springer Berlin Heidelberg, 2013. 99-126.

[8] United States. Office of the Chairman of the Joint Chiefs of Staff. *National Military Strategy to Combat Weapons of Mass Destruction*. Washington, DC: Chairman of the Joint Chiefs of Staff, 2006.

PerE-YIP-Topic 7: Epigenetics of Response to Radiation (Thrust Area 3)

Average Award Amounts for PerE-YIP-Topic 7 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 7.

PerE-Topic 8: Determining the Mechanistic Basis for Surface Interactions and Effects on Catalytic Efficiency in Tethered Enzyme Systems (Thrust Area 3)

Average Award Amounts for PerE-Topic 8:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 8:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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 charged with providing for sustainment of operations in CBRNE environments. At present, detection technologies are inadequate to fully characterize contaminated sites and provide sufficient early warning so that warfighters can use avoidance and protection strategies to prevent or mitigate exposures. The development of "remote detection" technologies (i.e., those removed from areas marked by high levels of contamination) is desirable in order to empower field commanders to make real-time or near-real-time decisions regarding appropriate protective postures prior to site entry.
The present topic seeks novel solutions for detection of signatures indicating proximity of processes associated with nuclear proliferation. Signatures are not limited to radioactive residues but can also include industrial solvents, heavy metals, and other chemicals such as those which denote production of explosives and propellants. The anticipated end-state capability is reliable differentiation of key signatures at low concentrations within complex aqueous matrices. Herein, the specific focus is on basic research to interrogate enzyme-based interfacial materials that will lead to development of highly selective and sensitive detection motifs.

Researchers continue to evaluate the use of enzymes as interfacial materials in detection platforms, primarily because of superior ability to bind specific analytes to the exclusion or near-exclusion of others. Their work further demonstrates that enzymes can be incorporated into well-characterized platforms, such as optical and electrochemical platforms, and establishes utility of those systems under specific conditions. However, enzymes are frequently labile (e.g., prone to chemical change) outside of the narrow range of conditions that promote activity in living systems, thus more recent research efforts have sought to increase durability in broader operational environments by tethering or immobilizing enzymes on synthetic substrates.

Proof-of-concept experiments indicate that enzymatic activity can be retained by engineering enzymes with precisely-placed chemical linker molecules which promote favorable active site orientations. Retention of activity for enzymes tethered to simple, well ordered substrates like self-assembled monolayers is demonstrated, and the work provides important insights regarding surface-enzyme interactions that lead to reduced catalytic

efficiency. However, it is not substantially predictive of enzyme behavior in more complex strata. While the combination of enzymes and complex substrates offers far greater capacity for manipulation and, ultimately, development of more powerful detection systems, recent work shows that use of disordered substrates (e.g., polymers) leads to localized destabilization and changes in surface loading that can alter material properties in an unpredictable fashion. It is therefore desirable to expand upon current research efforts in order to investigate interactions among complex substrates, linker molecules, and enzymes with the end goal of developing interfacial materials that optimize the desired attributes of selectivity, sensitivity, and stability.

Impact: The fundamental knowledge generated as a result of conducting the research described here will be broadly applicable to core DTRA requirements for supporting the warfighter during CBRNE operations. In addition to addressing existent capability requirements, detailed characterization of enzymatic systems will provide the baseline understanding necessary to rapidly engineer enzyme-based defense technologies in response to novel and emerging threats. Finally, the development of enzyme-based technologies to address a number of diverse mission needs is of paramount interest to the DoD and is critical to maintaining technological advantage.

Objective: The overarching goal is to interrogate complex substrate-linker-enzyme interactions that alter stability and/or efficacy of enzyme-based systems in order to elucidate contributing mechanisms. Model enzymes may serve as the basis for preliminary work, but those with relevance to detection of signatures discussed in the background section should be evaluated in studies proposed for the latter stages of the work plan.

Research areas may include but are not limited to the following:

- Alterations to enzyme activity and stability resulting from differences in chemical linker attachment points
- Impact of length and composition of chemical linker groups on enzymatic structure, activity, and stability
- Localized unfolding/disruption to enzyme conformation due to interactions between side-chain residues and substrate
- Other electrostatic, stereochemical, and electrochemical effects that impact catalytic efficiency or enzyme stability
- Sequential modification to substrate properties due to surface loading and/or other factors

Experimental conditions (e.g., pH, temperature, and so on) should be well-delineated *a priori* so that systematic evaluation of possible contributing factors and combinations of factors can be investigated. Although computational modeling is recognized as a necessary component of the above research, a purely computational approach is not considered competitive.

PerE-YIP-Topic 8: Determining the Mechanistic Basis for Surface Interactions and Effects on Catalytic Efficiency in Tethered Enzyme Systems (Thrust Area 3)

Average Award Amounts for PerE-YIP-Topic 8 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 8.

PerE-Topic 9: Understanding X-ray Interactions that Lead to Arc Formation in Solar Arrays (Thrust Area 3)

Average Award Amounts for PerE-Topic 9:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 9:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: Space systems are used to coordinate mission-critical information in all operational systems which impact the mission performance of the U.S. warfighter; policy, logistics, operations, reconnaissance, planning. Photovoltaic arrays are the components which power these systems in orbit around the Earth. To guarantee support when it is needed, these arrays and the systems they power must have very high reliability which includes robustness against nuclear radiation prompt doses.

Most modern satellites employ solar arrays that consist of multiple III-V (e.g., InGaAs/GaAs/InGaP2/etc.) three-junction cells connected in series to form "strings" to achieve the desired voltage. The strings of cells are constructed in parallel connections to achieve the necessary current and the solar cells are typically protected by anti-reflective coated (e.g.: MgF2) cover glasses. The space radiation environment (high energy electrons, X-rays, gamma rays, etc.) generates a spatially varying net charge across the surfaces of the solar array resulting in large electric potential differences between the surfaces. This, in combination with the high voltages of the strings of cells, can cause a dielectric breakdown of the array materials allowing electric arcing.

Arc formation is assisted by the presence of conductive plasma, created either by the environment or by another arc. Primary arc formation is typically caused by a dielectric breakdown between the over-charged cover class and the high voltage solar array. The plasma generated by this primary arc facilitates the formation of secondary arcs between adjacent strings of cells. These secondary arcs can become self-sustaining by feeding off both the power of the solar array as well as the generated plasma, diminishing or destroying the array.

How the prompt dose radiation environment from a nuclear event in space affects the arc formation in satellite solar arrays is currently not well understood. There is much room for exploration of how cold X-rays generate high-density blow-off plasma due to the very high prompt dose of radiation to the first few microns of surface materials. The subsequent potential to support arc formation in the presence of plasma, the nature of the plasma, the behavior of the plasma in a high voltage environment are also not well understood or modeled.

As an example, the blow-off of a highly conductive plasma layer has been observed in experiments using the Omega laser at the University of Rochester Laboratory for Laser Energetics. The Omega laser was used to drive an aerogel target to generate ~2 nanosecond long x-ray pulses. Langmuir probes biased at 10-30 V and solar cells biased at 100 V were used to measure the effects of plasma blow-off. The fluence at the probes and cells of x-rays with energies below ~1 keV ranged from 0.03 – 0.3 Joule/cm^2. In all cases, the probes and solar cells exhibited the effects of a conductive surface plasma.

Impact: Understanding the mechanisms which govern arc formation and its scaling will direct future design efforts to manage these events and their consequences on space systems. The expectation is that this will eventually result in better, more cost-effective ways of designing future space system solar arrays that are not

vulnerable to natural and nuclear radiation effects.

Objectives: The overall objective of this topic is to explore the fundamental physics of the generation and properties of the warm, dense plasma that may drive primary and secondary arc formation under enhanced radiation conditions. Experimental, theoretical, modelling, and computational efforts that accurately describe, predict, and replicate the phenomenon are of interest to DTRA. All efforts should be focused on discovering the fundamental science that drives the arc formation in the enhanced radiation environment, not on engineering approaches that seek to develop new method for mitigation or new solar array designs.

Research areas may include but are not limited to the following areas:

- The time-dependent interaction of x-rays (with a range of effective blackbody temperatures from 100 to 1000 eV) with a variety of metallic and insulating materials that drive the blow-off and ionization of surface layers

- The nature of electrical conduction properties of the surface plasma generated in the aforementioned range. Models should be validated with experiments using laser- or pulsed-power-driven x-ray sources

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PerE-YIP-Topic 9: Understanding X-ray Interactions that Lead to Arc Formation in Solar Arrays (Thrust Area 3)

Average Award Amounts for PerE-YIP-Topic 9 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 9.

PerE-Topic 10: Techniques, Methods, and Structures for Characterizing Radiation Effects in Emerging Nanoscale Memory and Logic Materials and Devices (Thrust Area 3)

Average Award Amounts for PerE-Topic 10:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 10:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: Commercial microelectronics (memory and logic devices) continue to decrease in size, increase in complexity, and incorporate emerging electronic materials. There are a wide variety of emerging electronic

materials (III-Vs, 2D materials, high-k dielectrics, and carbon-based materials) and new device structures (FinFETs, MTJs (magnetic tunnel junctions), nanowire (gate all around) FETs, single layer/few layer devices) that are of potential interest for DoD systems. Before these materials and devices can be incorporated in DoD systems the effects of radiation (total ionizing dose, displacement damage, and single events effects) must be well understood and adequately modeled. While many characterization techniques, methods, and structures have been developed to understand these effects in silicon devices, these techniques are not sufficient to fully characterize emerging memory and logic devices. New techniques, methods, and test structures are needed to both increase the fundamental understanding of radiation effects in these materials and devices as well as allow for quicker and earlier determination of a device's potential utility in high radiation environments.

Recently techniques such as high resolution transmission electron microscopy (HRTEM), atom probe tomography, and Raman spectroscopy have been applied to characterizing fundamental radiation effects in microelectronic materials and devices. There has been significant progress in the development of new, or refinement of established, analytical characterization techniques in other fields such as nanotechnology, biotechnology, and materials science that could potentially be adapted to the study of radiation effects in emerging memory and logic devices.

It is also critical that these characterization techniques, methods, or test structures be integrated with or connected to models (e.g. molecular dynamics, energy deposition, device function, or circuit function) to ensure that improved physics understanding is rapidly transitioned to device, circuit, and component design.

Impact: New and improved characterization techniques, methods, and test structures for identifying and understanding radiation effects in emerging nanoscale memory and logic materials and devices will shorten the timeline for adopting promising microelectronic technology while reducing the risks of unknown radiation effects. It is expected that these emerging technologies will improve the speed and power of microelectronics in DoD systems while reducing power consumption and increasing device reliability.

Objective: To develop new or improved techniques, methods, or test structures for identifying and characterizing the effects of radiation (gamma, neutron, ion, and high energy electron) on emerging electronic materials and devices (memory and logic). This topic is not focused on a particular technology or material, but rather on broadly applicable techniques, methods, and structures. This topic is **not** interested in radiation detection or dosimeters.

Of particular interest are techniques, methods, or test structures that can:

- Characterize radiation effects in emerging memories including but not limited to resistive random-access memory (RRAM), magnetic RAM (MRAM), spin torque transfer MRAM (STT-MRAM), phase change memory, and three dimensional RAM
- Address the challenges of characterizing radiation effects in nanoscale structures, thin (down to monolayer) films, and two dimensional materials including but not limited to charge collection, interface effects, and environmental/passivation effects.
- Use of novel test devices to characterize single event effect vulnerability in small geometry, advanced devices where only single-channel devices can be fabricated
- Provide a quantitative correlation between pulsed laser single event testing, ion testing, and modeling/theory
- Provide representative radiation effects results with early devices that may not be representative of final device structure
- Identify and characterize atom level defects in situ or with minimal sample preparation

Prospective investigators are encouraged to collaborate with NASA, DoD, DOE and other federally sponsored and overseas facilities in order to facilitate transition of the research to be performed to practice.

PerE-YIP-Topic 10: Techniques, Methods, and Structures for Characterizing Radiation Effects in Emerging Nanoscale Memory and Logic Materials and Devices (Thrust Area 3)

Average Award Amounts for PerE-YIP-Topic 10 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 10.

PerE-Topic 11: Chemistry of Chemical Agents, Simulants and Precursors (Thrust Area 4)

Average Award Amounts for PerE-Topic 11:

- Single Scope Awards will average approximately $100,000 to $150,000 per year.
- Multidisciplinary Awards will average approximately $200,000 to $350,000 per year.

Award Structure for PerE-Topic 11:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: Counter-WMD operations in non-permissive or access-denied environments often rely on conventional weapons with energetic material payloads to defeat WMD targets. Current conventional weapons contain explosives and future custom-designed counter-WMD weapons will include reactive materials that continue to burn over longer periods of time than a conventional explosive. It is important to understand the effect of burning, variable heating rates, high temperature and temperature duration, on chemical agents that could be contained in a WMD target, and asymmetric heating rates arising in multi-room structures (thermal delay/shielding). What intermediate reactive species and final products are formed as chemical agents/simulants/precursors are subjected to variable high temperatures and heating rates? What are the thermal degradation conditions and reaction rates? It is important to consider if any thermal decomposition products or intermediate products are harmful or toxic. Further, since future weapons may contain reactive metals that burn to form metal oxides, or sulfates that form sulfides, or halogenated oxides that form halogens, any enhanced effect from metal oxides, sulfides or halogens are also of interest.

In addition, counter-WMD operations could potentially leak agents/simulants/precursors on to the floor or subsurface areas, which could be various porous (such as concrete, soil, etc.) or cracked/broken surfaces. Depending on the floor surface, pH of the surface, chemical composition of the surface, polyvalent cation concentrations, etc., a certain amount of agents/simulants/precursors may be neutralized in the surface or dispersed by water after it had been absorbed in to the surface.

Both effects, destruction during the counter-WMD operation and post-operation neutralization by the environment, need to be characterized and understood to evaluate the full effect of counter-WMD operations on

targets containing chemical agents, simulants and precursors. Therefore, this topic seeks basic research on high-temperature decomposition reaction mechanisms and kinetics chemical agents, simulants and precursors, to include studies in the presence of metal oxides, sulfides or halogens; and considering various types of floor surfaces such as concrete, soil, etc.

Impact: The success of this research would provide essential characterization and kinetic parameters that will put adversarial WMD targets at risk, particularly those with chemical agent. This research is also critical for predicting a weapon's effectiveness and lethality against chemical-agent containing WMD targets.

Objectives: This research topic seeks chemistry of chemical agents, simulants and precursors. White papers proposing experiments or modeling will be considered.

Research areas may include but are not limited to the following:

- Reactions, reaction mechanisms and kinetics of chemical agents and/or simulants and/or precursors when heated at varying heating rates from 10,000 degrees per second to 100 degrees per second, to high temperatures from 300K to 2,000K
- Reactions, reaction mechanisms and kinetics of chemical agents/simulants/precursors heated in the presence of metal oxides, sulfides or halogens when heated at varying heating rates from 10,000 degrees per second to 100 degrees per second, to high temperatures from 300K to 2,000K
- Considering various types of floor surfaces such as concrete or soil, on reactions, kinetics, and mechanisms of chemical agents/simulants/precursors

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PerE-YIP-Topic 11: Chemistry of Chemical Agents, Simulants and Precursors (Thrust Area 4)

Average Award Amounts for PerE-YIP-Topic 11 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 11.

Period E-Topic 12: Alternative Signatures and Characterization Methods for Monitoring Potential CBRN Sites (Thrust Area 5)

Average Award Amounts for PerE-Topic 12:

- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerE-Topic 12:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- 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. See Section II.1.1 for details on the possible structure of awards under this BAA.
- 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: Operations at sites used for storing, handling, or testing WMD may comply with recognized treaties or agreements and monitoring systems exist that can help support verification of compliance. WMD development and proliferation has also occurred outside of treaties or agreements and may include advances by nations or subnational groups. This introduces uncertainties that further complicate efforts to reduce the WMD threat. Both cooperative and non-cooperative cases benefit from identification and exploitation of additional, novel signatures to provide alternative means of indicating development of WMD. In addition to nuclear proliferation, non-nuclear WMD developments need to be addressed.

Physical and life science methods can contribute to innovation in identifying and exploiting novel signatures. New materials and techniques in nanoscience, mass spectrometry, spectroscopy, quantum sensing, imaging, isotope analysis, and radiometry are examples of physical science methods that continue to push the envelope of sensitivity, selectivity, and reduction of false positives.

In order to verify treaty compliance but protect state secrets, rapid and reliable conclusions about the provenance of an item presented to an inspectorate must be produced. These methods must be scientifically sophisticated enough to conclusively identify the composition and time-dependent radiation exposure history of a component from a dismantled nuclear weapon system. As a complement to conventional nuclear detection techniques, unique physicochemical signatures may be a valuable way for the onsite inspection (OSI) team to determine if the object presented matches its declared use and history. Other goals include those techniques that can be used with area or remote collection of samples to understand processes at a facility of interest and identify the likely presence of WMD materials.

Life science techniques may seek to find pathways and accumulation mechanisms for chemicals and isotopes to enter into flora, fauna, and biota in general. A challenge is to make such methods very sensitive, and to seek techniques that cover accumulated concentrations less than parts per million and desirable to much less than parts per billion; i.e., ultra-trace.

Impact: Successful innovations from this basic research will improve understanding of signatures that identify and describe WMD development and proliferation. This will impact the ability to assure treaty and agreement compliance across chemical, biological, radiological, and nuclear WMD, as well as provide capabilities for identifying proliferation activities associated with CBRN proliferation. This will also provide ability to reduce uncertainties surrounding site activities in non-cooperative situations such as may arise in conflict requiring military action to counter WMD.

Objective: Investigate theoretical, experimental, and/or modeling approaches to novel signatures for characterization. Studies addressing radioactive contamination at sites should address intensities between 0.01 and 100 millirads/hour to cover cases ranging from approximately natural background to hot spots holding very radioactive sources. Much smaller dose rates indicating trace presence of isotopes is also sought. Studies examining chemical signatures should focus on trace or ultra-trace methods, and quantify sensitivities (e.g., nanomolar or much smaller concentrations achieved?) to advance state-of-the-art for the signature studied.

Research areas may include but are not limited to the following:

- Explore methods for rapid identification and characterization of readily exploitable isotopic-based differences that support characterization of site processes, identification of components and their origins. Advances in determining global background variation, mass spectrometry, nanoscience mechanisms, spectroscopy and other means may be used to perform ultratrace analysis and identification.
- Investigate chemically reactive signatures for chemical, nuclear, or biological WMD production activities. The focus is not on WMD agents but on indirect indicators such as may identify missile testing, WMD production techniques, or other supporting activities in WMD system development.

- Determination of unique physicochemical signatures through advanced analysis techniques such as:
    - Mass spectrometry such as SIMS or GC-MS to look for changes in the elemental or molecular composition of the material
    - Microscopy techniques such as AFM or SEM to identify microstructural or morphological changes
    - Optical or surface spectroscopy such as Raman spectroscopy or ellipsometry to identify subtle chemical or physical property changes
    - Bulk measurement techniques such as nanoindentation or conductivity tests to quantify changes in hardness or charge mobility
    - Imaging techniques such as hydroacoustic imaging or x-ray to probe subsurface structural shifts or defects
- Novel methods to investigate both time-integrated and time-dependent radiation exposure history of a component to assist with verification of items found at a facility.
- Methods to distinguish between physicochemical signatures of operational radiation exposure and artificial aging of a component from a variety of radiation sources, both stockpile-relevant and relevant for understanding origins.
- Methods that enable site profiling and verification of presence of processes or materials, by investigation of natural biological source specimens local or remote to a site that provide biomarkers/bioindicators of WMD-related materials or activities. This may be achieved by means of indicators related to uptake of WMD-related: chemicals; isotopes (including non-radioactive ones that may be signatures); or radioactive and nuclear materials. The research focus may include transport in air/water/earth (including relation of transport processes to bioaccumulation / biomagnification of WMD interest), accumulation pathways (i.e., advance the understanding of how such processes relate to bioavailability and concentration factors to advance knowledge of how the concentration in an organism relates to environmental concentrations of chemical X), biological (or other) half-lives, and means to readily extract trace or ultra-trace indicators (either physical extraction or information read-out methods, such as means for sensing or interrogation of biological markers of exposure) from exposed biological samples.

PerE-YIP-Topic 12: Alternative Signatures and Characterization Methods for Monitoring Potential CBRN Sites (Thrust Area 5)

Average Award Amounts for PerE-YIP-Topic 12 will be approximately $100,000 per year.

For topic description and award structure see PerE-Topic 12.

JSTO-CBD Basic Research Needs

The Chemical / Biological Technologies Department basic research program targets strategic, mission-focused basic research investments with high potential impact for the US Chemical and Biological Defense Program (CBDP). Chem-Bio Basic Research is seeking new and innovative proposals for fundamental research in the following topics:

PerE-Topic 13: Discovery of Secreted Circulating and In Vivo Amplified Bacterial Antigens (Thrust Area 3)

Average Award Amounts for PerE-Topic 13:

- Single Scope Awards may be up to $500,000 per year. Further guidance on scope and cost may be provided in each full proposal invitation.
- Multidisciplinary Awards may be up to $1,000,000 per year. Further guidance on scope and cost may be provided in each full proposal invitation.

Award Structure for PerE-Topic 13:

- Will be for a base period of two (2) years with up to one (1) additional year as a possible option.
- Pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable.
- Note that pre-application white papers and proposals that outline scope and effort that exceed a total of three (3) years will not be considered.

Background: Efficacious therapeutic counter-measure use for treatment of infection with highly pathogenic bio- and emerging threat agents is firmly dependent on early identification and diagnosis of acute infection with a bacterial or viral pathogen. However, accurate identification and immuno-diagnosis requires capture and detection of trace amounts of circulating microbial antigens and is severely complicated by their presence in bodily fluids/complex biological specimen matrices such as whole blood and serum. Also, many pathogens have developed mechanisms to evade host immune system detection and response by limiting replication to low pathogen load concentrations. In addition, accurate identification is an important component of good antimicrobial stewardship so that resistance fitness mechanisms are not further enhanced. Houghton et al[1] recently published a promising approach for the diagnosis of using such a system that is undergoing clinical evaluation for the identification of virulent Burkholderia species. A sufficiently sensitive device will demonstrate such a biomarker could be developed into a rapid screening assay.

Impact: The discovery and identification of such novel biomarkers that are expressed at high copy number in the bloodstream would enable rapid detection of pathogen while in the proximity of healthcare provision. Rapid diagnosis of antigens that are shed into body fluids during infection and which yield an in vivo amplified target marker would improve the predictive value of multiplex syndromic diagnostic tests.

Objective: Fundamental research is sought using a "discovery platform" (i.e., a broad and reproducible systematic approach) for identification of novel, alternate biomarkers of sufficient sensitivity to detect bacterial bio- or emerging threat agents. The ideal approach will focus on exploiting natural or modified virulence factors or non-structural elements in the secretome that yields copy numbers amplified by enzymatic or non-enzymatic processing and shed directly into the blood stream as active form and/or in urine as active or metabolite forms. Proposed approach should be demonstrated kinetically. Applicability should be demonstrated either in:

- Both gram negative and gram positive bacterial pathogen or
- Both bacterial and viral pathogen antigens

Ultimately, biomarkers should be compatible with Point-of-Need (PON) diagnostic and bio-surveillance devices capable of use under austere environmental conditions. Host response biomarker discovery is not responsive to this solicitation topic.

[1] Houghton RL, Reed DE, Hubbard MA, Dillon MJ, Chen H, et al. (2014) Development of a Prototype Lateral Flow Immunoassay (LFI) for the Rapid Diagnosis of Melioidosis. PLoS Negl Trop Dis 8(3): e2727

PerE-Topic 14: Signatures of Antimicrobial Resistance Detectable by Minimally Invasive Means (Thrust Area 3)

Average Award Amounts for PerE-Topic 14:

- Single Scope Awards may be up to $350,000 per year. Further guidance on scope and cost may be provided in each full proposal invitation.
- Multidisciplinary Awards may be up to $700,000 per year. Further guidance on scope and cost may be provided in each full proposal invitation.

Award Structure for PerE-Topic 14:

- Will be for a base period of two (2) years with up to one (1) additional year as a possible option.
- Pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable.
- Note that pre-application white papers and proposals that outline scope and effort that exceed a total of three (3) years will not be considered.

Background: The goal of this topic is to identify and characterize signatures specific to drug resistant biothreat-relevant microbes through rapid and minimally invasive means. Such markers could include, for example, volatile organic compounds (VOCs) or secreted metabolites. Recent analyses of bacterial headspace samples have demonstrated the identification of microorganisms including distinguishing between antibiotic susceptible and resistant substrains of *S. aureus* by profiling a range of VOCs[1,2] and discriminating between pathogenic bacteria[3]. Such findings open the potential for revolutionizing diagnosis and treatment of emerging biothreats such as antibiotic resistant (AMR) bacteria by enabling earlier identification via analysis of ambient, inhaled, or exhaled air. The acquisition of antibiotic resistance has also been found to lead to major metabolic changes, including the production of secondary metabolites which could be used to non-invasively identify AMR threats including multi-drug resistant MDR threats[4]. Understanding of the biomarker profiles of AMR and MDR resistance in specific microbial biowarfare threats such as *F. tularensis* and *Y. pestis*, or more desirably in a manner generic to numerous such biothreats, would allow for more accurate mechanistic assessment of the time and spatial course of microbial evolution and infection as well as earlier decision regarding proper medical response.

Impact: Identification of readily accessible signatures of antibiotic resistance will primarily enable earlier identification of emerging biothreat pathogens, therefore earlier and more targeted treatment of exposures to antibiotic- or multidrug-resistant strains of such pathogens. The potential also exists to enable an improved mechanistic understanding of biothreat fate to enable improved battlefield risk assessment.

Objective: Identify and characterize signatures specific to the acquisition of antimicrobial resistance and/or multidrug resistance by biowarfare agents to include *F. tularensis* and *Y. pestis*, in a manner that may be applied with small modification to numerous other biothreat pathogens. In addition, develop proof-of-principal means to sample these signatures in a minimally invasive manner.

Identification and characterization of such signatures might rely in part upon improved mechanistic understanding or *in-silico* models; however, such activities must be coupled with experimental validation and proof-of-concept exploitation of this new understanding of dynamic biomarker profiles. Stand-alone modeling approaches or advanced development activities are not within the scope of this topic.

[1] A. W. Boots, J. J. B. N. van Berkel, J. W. Dallinga, A. Smolinska, E. F. Wouters, F. J. van Schooten, "Identification of microorganisms based on headspace analysis of volatile organic compounds by gas chromatography—mass spectrometry," *J. Breath Res.* **2014**, 8, 027106. DOI: 10.1088/1752-7155/8/2/027106.

[2] S. H. Lim, S. Mix, Z. Xu, B. Taba, I. Budvytiene, A. N. Berliner, N. Queralto, Y. S. Churi, R. S. Huang, M. Eiden, R. A. Martino, P. Rhodes, N. Banaei, "Colorimetic Sensor Array Allows Fast Detection and Simultaneous Identification of Sepsis-Causing Bacteria in Spiked Blood Culture," *J. Clin. Microbiol.* **2014**, 52, 592-598. DOI: 10.1128/JCM.02377-13.

[3] C. L. Lonsdale, B. Taba, N. Queralto, R. A. Lukaszekski, R. A. Martino, P. A. Rhodes, S. H. Lim, "The Use of Colorimetric Sensor Arrays to Discriminate between Pathogenic Bacteria," *PLOS ONE* **2013**, 8, e62726. DOI: 10.1371/journal.pone.0062726.

[4] D. K. Derewacz, C. R. Goodwin, C. R. McNees, J. A. McLean, B. O. Backmann, "Antimicrobial drug resistance affects broad changes in metabolomics phenotype in addition to secondary metabolism," *Proc. Nat. Acad. Sci.* **2013**, 110, 2336-2341. DOI: 10.1073/pnas.1218524110.

PerE-Topic 15: Multi-Functional Plasmonic Nanomaterials for Personal Protection (Thrust Area 3)

Average Award Amounts for PerE-Topic 15:

- Single Scope Awards may be up to $300,000 per year. Further guidance on scope and cost may be provided in each full proposal invitation.
- Multidisciplinary Awards may be up to $500,000 per year. Further guidance on scope and cost may be provided in each full proposal invitation.

Award Structure for PerE-Topic 15:

- Will be for a base period of three (3) years with up to two (2) additional years as possible options.
- Pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable.
- 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 DTRA Chem Bio Defense Program (CBDP) is interested in the detection, protection, decontamination and destruction of chemical and/or biological agents in order to protect personnel and retain the utility of materiel assets. Consequently, functional materials that adsorb and catalytically degrade or decontaminate chemical warfare agents (CWAs) or toxic industrial chemicals (TICs) are critically important. Usually, the first line of defense is in the form of protective gear, such as suits, gloves, masks, and filtration materials. There are current efforts in producing fabrics that repel agents on contact, as well as materials that act as self-cleaning surfaces. Current filtration materials typically are comprised of activated carbon impregnated with Cu and/or Zn metal/oxide catalysts, while promising new filtration materials under development include polyoxometallates (POMs) and metal organic frameworks (MOFs).

The CBDP is interested in understanding the fundamental materials properties of non-precious metal plasmonic nanohybrid (metal/metal-oxide) material systems with a focus on elucidating the nanohybrid structure/function relationships that control the adsorption and catalytic reaction mechanisms as well as enhancement processes for spectroscopic detection. In recent years, the creation and characterization of nanoscale materials has enabled a wealth of new possibilities for the design of new material functionalities into mesoscale architectures. Recognition of the influence of heterogeneous surfaces on electron and molecular transport within mesoscale materials has led to new design and materials performance paradigms in energy storage and catalysis. Likewise, recent research and understanding of optical interactions with nanostructures has resulted in new perspectives on photocatalytically active materials and processes. While much of the rapid progress in plasmonics and plasmonic photocatalysis has focused on precious metal nanoparticles, such as platinum, gold, or silver, on oxide supports, there is opportunity for the development of alternative less-expensive photocatalytic plasmonic nano-hybrid materials.

Objective: The goal of this research topic is to provide advanced functional materials for protection from, and elimination of, chemical warfare agents (CWAs) and/or toxic industrial chemicals (TICs). Through this topic, the CBDP aims to capitalize on recent advances in nanomaterials, plasmonics and photocatalysis to explore the

fundamental properties of multifunctional plasmonic nanohybrid materials in the context of adsorption and photocatalytic detoxification of target chemical agents, such as CWAs (e.g. mustard and sarin, or their simulants (e.g., 2-chloroethyl ethyl sulphide (CEES) and dimethyl methyl phosphonate (DMMP)), and TICs (e.g., HCN, NH_3, NO_2, and CH_3Br). It is anticipated the plasmonic processes will be driven by visible or possibly infrared light, and will entail a rigorous optical and molecular characterization of the processes necessary for understanding the mechanisms of CWA and/or TIC adsorption and photocatalytic decomposition. For the materials developed within the program to have the greatest relevance, they must not be toxic and shall minimize the use of precious metals, such as platinum, gold or silver, while either enhancing the catalytic destruction of CWAs and/or TICs compared to current filtration materials, or enhancing agent detection. It is expected that detailed understanding of the plasmonically-enhanced catalytic and/or sensing mechanisms will be developed through rigorous optical and molecular characterization of the materials and the decomposition processes in combination with modeling and theory.