DEFENSE THREAT REDUCTION AGENCY

BROAD AGENCY ANNOUNCEMENT

HDTRA1-11-21-BRCWMD-Service Call for DoD Degree-Granting Academic Institutions

Amendment 5 (December 2015)

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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1. Introduction and Scope

1.1. This solicitation is an intramural endeavor focused on the basic research needs of DTRA. DTRA has 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 (CBRNE). DTRA seeks to identify, adopt, and adapt emerging and revolutionary sciences that may demonstrate high payoff potential to counter WMD threats.

1.2. This Service Call solicits 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 DTRA. Responses to this Service Call must be unclassified and must address **only basic research**. 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 non 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]

2. Purpose and Research Topics

2.1. 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 10. 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.

[1] DoDI 3210.1, September 16, 2005

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

- ***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.

2.2. In Period F, DTRA seeks unclassified, basic research ideas that are responsive to the goals and objectives of the topics outlined in Section 10. The topics labeled "PerF" are only valid for Period F of this Service Call. Only white papers responsive to the topics posted for Period F and submitted by the Period F deadline by eligible applicants will be considered. A new list of topics will be developed for subsequent periods with corresponding white paper due dates.

2.3. Topics for future periods with corresponding white paper due dates will be accomplished via amendments to this solicitation. Topics from previous period(s) 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 Service Call.

2.4. This Service Call, in addition to any amendments issued in conjunction with this Service Call, will be posted to the DTRA Submission Website (www.dtrasubmission.net), the DTRA Basic and Fundamental Research Community Portal (www.dtrasubmission.net/portal) and to the DTRA website (www.dtra.mil).

2.5. The DTRA Basic and Fundamental Research Community 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 Service Call, templates that may be used when preparing white papers and invited proposals, and an update on the status of

submission(s).

3. Award Information

3.1. Resulting awards from this announcement will be Military Interdepartmental Purchase Requests (MIPRs). The final number of projects and funds allocated will be determined after all proposals are received and evaluated.

3.2. 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 3.2) 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. White papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable

3.3. There are three 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 white paper is submitted.

- Single Scope Awards: Research projects that focus on exploratory aspects of a unique problem, a high risk approach, or innovative research in a subject 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), sub-awards, and/or sub-contracts. Single Scope Awards will be made by a single MIPR to the lead organization. Sub-awards, including all sub-contracts, are the responsibility of award recipient; exceptions will not be made.

  Single Scope Awards will average $150K per year (average award values include both direct and indirect costs).

  The predominance of awards will be Single Scope Awards.

- 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 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 white paper and the invited proposal. Multidisciplinary Awards will be made by a single MIPR to the lead institution. Sub-awards, including all sub-contracts, are the responsibility of award recipient. Exceptions will not be made.

Multidisciplinary Awards will average $350K per year (average award values include both direct and indirect costs).

- 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 DoD degree-granting academic institution 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 MIPR to the lead organization. Subawards, including all sub-contracts, are the responsibility of the award recipient; exceptions will not be made.

  Young Investigator Awards will average $100K per year (average award values include both direct and indirect costs).

3.4. 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.

3.5. Sub-awards are permitted. Sub-awards may be used to carry out a portion of the research. DTRA will review and consider the proposed sub-awards for all applications on a case-by-case basis.

Any applicant submitting a proposal for an award that has subcontracting possibilities must submit a subcontracting plan in accordance with FAR 19.704(a) (1) and (2). This information, if applicable, must be included in Volume III, Supplemental Information, of the Phase II full proposal. The plan format is outlined in FAR 19.7.

3.6. Funding Restrictions. There are no known funding restrictions at this time.

3.7. The Government will not provide any hardware or software to execute the proposed research.

3.8. The Government reserves the right to fund all, some, or none of the proposals submitted; may elect to fund only part of any or all proposals; and may incrementally or fully fund any or all awards under this Service Call. All awards are subject to the availability of funds.

4. Eligibility

4.1. 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 white papers and proposals in response to this intramural Service Call.

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

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

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

- Applicants (PI/Co-PIs) are **strongly** encouraged to minimize overlap in scope and level of effort if multiple projects are submitted for 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 Service Call.

5. Submission Information

This solicitation will be conducted in two phases: Phase I is for submission of white papers. Phase II is by invitation only and is based on the evaluation results of Phase I. The invitation to submit a Phase II proposal will be based on the evaluation results in Phase I.

The submission deadline for Period F Phase I white paper receipt is listed in Section 6.

5.1. General Application and Submission Information.

5.1.1. All applicants interested in submitting proposals must register on the DTRA proposal submission website, http://www.dtrasubmission.net, prior to submission of a white paper(s) and proposal(s). Each institution may establish procedures for the management of registration and submission of proposals. Detailed registration instructions are available at the website. Failure to register in accordance with instructions will prevent submission of the required documents and render applicants ineligible for participation in this Service Call. Prior registration at any other proposal submission site other than at http://www.dtrasubmission.net does not fulfill registration requirements for participation in this Service Call.

5.1.2. Proposals must be submitted electronically through the DTRA proposal submission website, http://www.dtrasubmission.net. Do not submit any classified materials to the Service Call or to the proposal submission website. Unclassified proposals submitted by any means other than the DTRA proposal submission website (e.g., hand-carried, postal service mail, commercial carrier, or e-mail) will not be considered. Detailed submission instructions are available at the website.

5.1.3. Applicants are responsible for ensuring compliant and final submission of their white papers and/or proposals, and can verify the submission of the white paper and/or proposal package with the electronic receipt that appears on the screen following compliant submission of a proposal to the DTRA proposal submission website.

5.1.4. Using the DTRA proposal submission website, all applicants must prepare cover sheets for each Phase I white paper and invited Phase II proposal submitted. All data point requirements must be completed in every cover sheet. Once the cover sheet is saved, the system will assign a unique proposal number for each Phase I submission and a different unique proposal number for each invited Phase II submission. Cover sheets may be edited as often as necessary until the submission period closes.

5.1.5. If multiple proposals are being submitted by the same institution, separate cover sheets must be

generated for each white paper and proposal as the required documents must be uploaded with the associated cover sheet, since a unique document number will automatically be assigned to each submission by the electronic proposal tracking system. All documents submitted to the DTRA proposal submission website are considered works in progress and are not eligible for evaluation until the applicant submits the final proposal package for consideration. Applicants are responsible for ensuring compliant and final submission of their white papers and proposals; applicants can verify the submission of the white paper and proposal package with the electronic receipt that appears on the screen following submission of a white paper and proposal to the DTRA proposal submission website.

5.1.6. The white paper and all parts of the proposal must be uploaded in a Portable Document File (PDF) format compatible with Adobe Acrobat ® version 9.1 or earlier. DO NOT encrypt or add security layers to the file. The file must be self-contained, i.e. all figures and tables should be in the same file. Do not add other attachments or embed other files (other than fonts).

Applicants are responsible for performing a virus check on each submitted document. Each submitted electronic document will be scanned for viruses. If a virus is detected, the file will be deleted and this may cause rejection of the application.

5.2. DTRA will not review any of the following:

- White papers that attempt to address multiple topics.
- White papers that are submitted to topics from previous periods.
- Proposals for Phase II submissions that were not invited.

5.3. Phase I White Paper Submission and Content. Interested applicants are required to submit a four-page white paper. Each white paper must address only one of the Period F research topics detailed in Section 10.

5.3.1. Cover Sheet Information: The following information is required to complete a Cover Sheet for each white paper and proposal:

- Topic Number under which white paper/proposal is being submitted for consideration
- Title of proposed effort, which must be different than the topic title
- Applicant Institution name and address (this is based on the registrant submitting the proposal, and should be the institution, not the individual)
- Estimated Cost per year of performance
- Information on other submissions of same proposed effort
- Contact Information for PI and Business Points of Contact – Name, Title, Phone, Fax and Email
- Identification of proprietary information included in proposal submission (page numbers)
- Technical Abstract. The 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.

- Key Words/Phrases (limited to 8 key words)

The Cover Sheet is automatically populated with the following information:

- DUNS, CAGE and Tax ID numbers, as entered during registration (cannot be changed)
- Applicant, as entered during registration (cannot be changed)
- Address (can be updated)

5.3.2. White Paper Narrative Format: 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:

- 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). Note that dollar values in the Service Call include both direct and indirect costs.
- 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.
- The topic number and name should be included as a header on the white paper and in the text of the white paper.

5.4. Phase II - Full Proposal Submission and Content. The full proposal must be prepared in three separate volumes: Volume I – Technical Proposal; Volume II – Cost Proposal; and Volume III – Supplemental Information, to include an SOW and a Quad Chart.

5.4.1. Cover Sheet Information: The information described above in Section 5.3.1 is required to complete a Cover Sheet for each proposal in Phase II.

5.4.2. Technical Proposal: The 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 proposal must be provided in portrait layout. A **template** for the technical proposal format may be found online at www.dtrasubmission.net/portal (Microsoft Word format).

The technical proposal must include the following components:

- ***Abstract.*** The 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.
- ***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 sub-contractor 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 sub-tasks and the duration of performance of each in a Gantt or other suitably formatted chart.
- ***References.*** List any relevant documents referenced.

5.4.3. Volume II – Cost Proposal: The Cost Proposal should contain cost estimates sufficiently detailed for meaningful evaluation with a break-down of costs on an annual basis and by task. A narrative supporting the costs should also be included. The Cost Proposal does not have a page limit and may be provided in the applicant's preferred format. The Cost Proposal must be uploaded as a separate Portable Document File (PDF) compatible with Adobe Acrobat ® version 9.1 or earlier. A PDF is requested to ensure formatting remains consistent and appropriate.

The Cost Proposal should include the following information:

- Individual labor categories or persons (principal investigator, graduate students, etc.), with

associated labor hours and unburdened labor rates.

- Benefits and labor burden costs.
- Subcontract costs and type (the portion of work to be subcontracted and rationale). Submit a detailed description of the proposed subcontracted effort(s) and the projected cost(s). Note that separate cost proposals should be provided and incorporated into Volume II for any subcontracts.
- Consultant fees (indicating daily or hourly rate) and travel expenses and the nature and relevance of such costs. Note that separate cost proposals should be provided and incorporated into Volume II for any consultants.
- Travel costs and the relevance to stated objectives; number of trips, destinations, duration, if known and number of travelers per trip. Travel cost estimations should be based on the Joint Travel Regulations (JTR).
- Publication and report costs.
- Estimate of material and operating costs.
- Cost of equipment, based on most recent quotations and itemized in sufficient detail for evaluation. Clearly delineate any computer or IT equipment purchases.
- Communications and publications costs not included in overhead.
- Other Direct Costs.
- Indirect costs.[3]

Applicants shall plan and budget for travel to accommodate the two meetings outlined as follows:

- 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.

5.4.4. Volume III – Supplemental Information: This volume contains supplemental data. This volume must contain the items detailed as follows:

- A Quad chart for the effort must be uploaded. Please see below for details.

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[3] Indirect costs may be restricted to less than 35% of the total award 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 years 2011to 2015 Basic Research funds but may apply to future awards.

- A Statement of Work defining the major tasks and timelines for the effort must be uploaded. Please see below for details.
- A brief summary of any proposed Human Subjects research, or a confirmation that the proposed effort does not include Human Subjects research, must be entered.
- A brief summary of any proposed Animal Subjects research, or a confirmation that the proposed effort does not include Animal Subjects research, must be entered.
- A brief summary of any proposed Biosurety and Select Agent research, or a confirmation that the proposed effort does not include Biosurety and Select Agent research, must be entered.
- A statement of any potential Organizational Conflicts of Interest, or a confirmation of no conflicts, must be entered.
- A statement of Intangible Property Assertions.
- Authorized Offeror Personnel: Applicants must include the name, title, mailing address, telephone number, fax number, and e-mail address of the company and business point of contact regarding decisions made with respect to the applicant and who can obligate the proposal contractually. Also, identify those individuals authorized to negotiate with the Government.
- A statement outlining any current and pending support related to the proposed effort must be entered. This information must be included for each investigator listed in the proposal. This statement requires that each investigator specify all grants and contracts through which he or she is currently receiving or may potentially receive financial support.
- A Cost Summary, which is a form that captures the following total costs by year (this summary includes total numbers only; supporting detail is included in the Cost Proposal):
    - □ Direct Labor
    - □ Fringe Benefits
    - □ Subcontract Costs
    - □ Domestic Travel Costs
    - □ Foreign Travel Costs
    - □ Tuition Costs
    - □ Direct Materials and Supply Costs
    - □ Direct Equipment Costs
    - □ Publication Costs
    - □ Other Direct Costs
    - □ Indirect Costs

Quad Chart: The quad chart must be presented on 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 www.dtrasubmission.net/portal (Microsoft PowerPoint

format). A pictorial representation of the quad chart is provided in Figure 1 and includes the relevant fields that must be included in the Phase II proposal submission. The inclusion of the DTRA logo is not required.

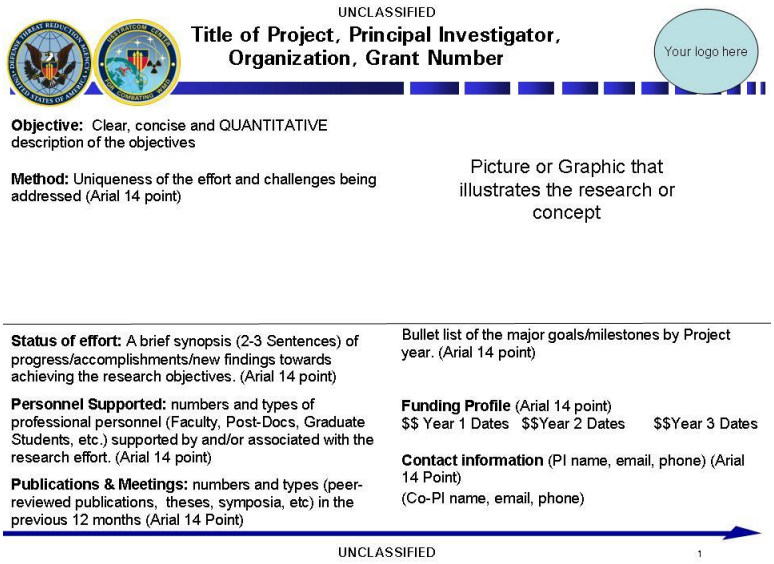

Figure 1: Pictorial representation of the quad chart.

SOW: SOW does not have a page limit, but should be approximately 3-5 pages in length and suitable for incorporation into the award document. The SOW should not contain any proprietary data or markings. Pages should be numbered and the initial page should have a date (document date) shown under the title (the title of the SOW should match that of the proposal). The SOW must be provided in portrait layout. A **template** for the SOW format may be found online at www.dtrasubmission.net/portal (Microsoft 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 Weapons of Mass Destruction (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 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 each task should be numbered 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 awardee shall" whenever the work statement expresses a provision that is binding. Use "should" or "may" whenever it is necessary to express a declaration of purpose. Use "will" in cases where no applicant requirement is involved; e.g., power will be supplied by the Government. Use active voice in describing work to be performed. Do not use acronyms or abbreviations without spelling out acronyms and abbreviations at the first use; place the abbreviation in parenthesis immediately following a spelled-out phrase. If presentations/meetings are identified in your schedule, include the following statement in your SOW: "Conduct presentations/meetings at times and places specified in the award schedule."

- ***Deliverables:*** The deliverables must include the following:

  □ 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. A Technical Reporting Guide may be found online at the www.dtrasubmission.net/portal.

  The Annual Report is *not* a cumulative report. The first Annual Report shall only include actions that occurred from the Period of Performance start date up to submission of the first Annual Report. Each subsequent report shall only include actions that occurred during the 12-month period following the previous year's Annual Report.

  In brief, awardees should plan to report on the following information in the annual Research Performance Progress Report: Accomplishments, Products, Participating/Collaborating Organizations, Impact and Changes/Problems. This information will be provided in a format to be directed by DTRA.

  □ Annual Quad Chart(s): At the direction of DTRA, an updated Quad Chart must be submitted. DTRA will provide instructions not later than 1 May of each year on how the Quad Chart is to be submitted

  □ Annual Metrics Survey: At the direction of DTRA, a Metrics Survey must be completed. DTRA will provide instructions not later than 1 May of each year on how the Metrics Survey is to be submitted. Note that the Metrics Survey is not a cumulative survey. The first Metrics Survey shall only include actions that occurred from the Period of Performance start date up to submission of the first Metrics Survey. Each subsequent report shall only include actions that occurred during the 12-month period following the previous year's Metrics Survey. Metric categories include, but may not

be limited to the following: Personnel Supported; Publications; Interactions/Transitions; Participation/presentations at meetings, conferences, seminars, etc.; new discoveries, inventions, or patent disclosures; Honors/Awards; courses taught; etc.

□ Research Performance Final Report: A comprehensive final technical report is required at the end of an effort, due before the end of the period of performance. A Technical Reporting Guide may be found online at the www.dtrasubmission.net/portal.

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).

□ Invention Reports: Invention reports must be filed annually, due no later than 1 July of each year. The recipient shall use DD Form 882, Report of Inventions and Subcontracts in accordance with the published instructions for the form **IF** the awardee has a reportable event. Negative reports are not required. The submission of the DD Form 882 is required at the conclusion of all awards.

5.5. Federal Financial Reports (SF-425) are due no later than 1 July of each year. MIPRs effective after 31 January will not require a Federal Financial Report until 1 July of the following year. All financial reports shall be submitted to dtrabasicresearch@mail.mil (file size must be less than 10MB). The file name should be the Year, 'Federal Financial Report' and the MIPR number, e.g. 2015 Federal Financial Report 9999-M. Marking of White Paper and Proposal and Disclosure of Proprietary Information other than to the Government. The white paper/proposal submitted in response to this Service Call 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 proposal evaluation. Public release of information in any white paper/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 white paper/proposal, it will be treated in confidence, to the extent permitted by law, provided that the following legend appears and is completed on the front of the white paper/proposal: "For any purpose other than to evaluate the white paper/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 White Paper/Proposal."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the 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 white paper/proposal data on lines specifically identified by asterisk (*) are subject to

the restriction on the front page of this white paper/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 white paper/proposal submitted in response to this Service Call 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 white paper/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 white paper/proposal, the applicant understands that proprietary information may be disclosed outside the Government for the sole purpose of technical evaluation. The Program Coordinator will obtain a written agreement from the evaluator that proprietary information in the white paper/proposal will only be used for evaluation purposes and will not be further disclosed or utilized.

5.6. 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 technologies. 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).

5.7. White papers and proposals may be withdrawn by written notice received at any time before award. Withdrawals are effective upon receipt of notice by the Program Coordinator via the e-mail address listed in Section 9.

6. Submission Dates and Times

6.1. White papers will be accepted based on periods as outlined in Table 1 (below). The due date for the Phase II invited proposal submissions will be provided in the letter of invitation. Applications will be reviewed under very limited circumstances if they are received after these deadlines. Additional timeline details are available to all applicants at www.dtrasubmission.net/portal, e.g. notification date for proposal invitations. Applicants are responsible for checking the www.dtrasubmission.net/portal for changes and updates to the schedule.

6.2. Applicants are responsible for submitting white papers and invited proposals so as to be received by the DTRA submission site by the time and dates listed in Table 1 (below) and the letter of invitation for proposals, respectively. When sending electronic files, the applicant should allow for potential delays in file transfer from the originator's computer server to the Government website/computer server. Applicants are encouraged to submit their proposals early to avoid potential file transfer delays due to high demand encountered as the submission deadline approaches.

6.3. Please note 15 USC 260a establishes daylight saving time as the standard time during the daylight saving period.

6.4. Additional opportunities for white paper submissions with applicable topics, due dates, and application packages will be posted as amendments to this Service Call. 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	Service Call announced on www.dtrasubmission.net/portal
Period A, Period B, Period C, Period D, and Period E are CLOSED	
Period F	
1 December 2015	Amendment to the Service Call announced on www.dtrasubmission.net/portal with Period F topics and white paper receipt deadline
1 February 2016	Phase I white paper receipt deadline
11:59pm EST, Not prior to 2 May 2016, and not later than 31 May 2016 *	Phase II invitation-only proposal receipt deadline
October—December 2016	Period F MIPRs scheduled to be awarded
Period G	
TBD	Amendment to the Service Call announced on www.dtrasubmission.net/portal with Period G topics and white paper receipt deadline
TBD	Phase I white paper receipt deadline
TBD	Phase II invitation-only proposal receipt deadline
TBD	Period G MIPRs scheduled to be awarded
Period H	
Period I	
…….	
Period 'n'	

Table 1: List of important dates.

6.5. 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 white paper and proposal to the DTRA submission site.

6.6. If the white paper and invited proposals are submitted to the DTRA submission site after the exact time and date specified in this Service Call for the white paper and the letter of invitation for the

invited proposal, the submission is "late" and will be reviewed at the discretion of DTRA.

6.7. If an emergency or unanticipated event interrupts normal Government processes so that proposals cannot be submitted to the DTRA submission site by the exact time specified in this Service Call for the white paper and the letter of invitation for the invited proposal, and urgent Government requirements preclude amendment of the Service Call closing date, the time specified for receipt of submissions will be deemed to be extended to the same time of day specified in the Service Call on the first work day on which normal Government processes resume.

7. Application Review Information

7.1. Evaluation Criteria. The evaluation criteria to be used for review of applications are listed below. Only the first two criteria will be used to evaluate white papers; all four 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 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 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 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.

7.2. Review and Selection Process. The white paper and proposal selection process will be conducted based upon a technical review and includes the use of non-government peer-reviewers. Each white paper and invited proposal will be reviewed within the period to which it was submitted.

7.2.1. White paper (Phase I) evaluation will be based on 2 equally weighted criteria described in Section 7.1: 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 white papers submitted, the results of the Phase I evaluation, and the specific needs of the Agency.

7.2.2. Invited Proposal (Phase II) Evaluation will be based on the 4 criteria described in Section 7.1. 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 4 criteria receive a numerical score ranging from 1 (unacceptable) to 5 (outstanding).

7.2.3. 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.

7.2.4. 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 Service Call and to make awards without discussions with applicants; however, the Government reserves the right to conduct discussions if determined necessary.

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

7.3. Technical and Administrative Support by Non-Government Personnel

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

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

7.3.3. Participation in this Service Call requires DTRA support contractors to have access to 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: Engility Corporation (advisory and assistance services) and their subcontractors, Suntiva Executive Consulting (contract specialist support) and their subcontractors, SBG Technology Solutions (automated solicitation proposal management system (ASPMS) support and their subcontractors, and Terremark Worldwide Inc. (ASPMS support). 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.

7.3.4. All individuals having access to any proprietary data must certify that they will not disclose any information pertaining to this Service Call including any submittal, the identity of any submitters, or any other information relevant to this Service Call.

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

8. Award & Notification Information

8.1. Applicants of white papers that are not selected for invitation will be notified of the decision by e-mail at all of the addresses provided at the time of submission.

8.2. 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 all of the email addresses provided at the time of submission.

8.3. Applicants will be notified by DTRA of their selection/non-selection for award from the Phase II invited proposals via email to all of the email addresses provided at the time of submission. Notification of proposal selection is not an authorization to begin work.

8.3.1. 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 MIPR 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.

8.4. A debrief summary will be provided as part of all notification emails.

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

8.6. The applicants must be aware that it is their responsibility to ensure 1.) correct emails are provided at the time of submission, 2.) this e-mail notification reaches the intended recipient, and 3.) the email 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.

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

9. Agency Contacts

9.1. All administrative and programmatic correspondence should be directed to HDTRA1-BRCWMD-SC@mail.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.

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

Thrust Area 1: HDTRA1-BRCWMD-TA1@mail.mil

Thrust Area 2: HDTRA1-BRCWMD-TA2@mail.mil

Thrust Area 3: HDTRA1-BRCWMD-TA3@mail.mil

Thrust Area 4: HDTRA1-BRCWMD-TA4@mail.mil

Thrust Area 5: HDTRA1-BRCWMD-TA5@mail.mil

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

9.2.2. Please reference the topic in the subject line of the email, as applicable.

9.2.3. Dialogue that assists the applicants in developing better white papers and invited proposals is encouraged.

9.2.4. Questions regarding debriefing summaries for white papers that are invited to full proposals are encouraged.

9.2.5. Requests to reconsider white papers and/or full 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.

10. Period F Topics

DTRA Basic Research Needs

PerF-Topic 1: Plasma Chemistry for Nuclear Forensics (Thrust Area 1)

Average Award Amounts for PerF-Topic 1:

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

Award Structure for PerF-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: Immediately after a nuclear detonation, complex chemical and physical processes take place in the fireball. The material from the device and the surrounding area interact as plasma which eventually cools to produce a condensate of physical material as fallout debris. An in-depth understanding of the thermodynamics and kinetics within the fireball, including mixing of various materials present at a detonation site, and the resultant particle agglomeration, particle size distribution, chemical speciation, and other related phenomena of fallout formation at the extreme temperatures and pressures within and near the fireball at time scales extending from initiation to multiple seconds is needed.

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. Currently, models such as DELFIC and HYSPLIT exist but increased fidelity will enhance the speed of response both in terms of fallout modeling and useful/effective debris sample acquisition. Of interest are innovations that will help provide more robust and accurate information used to predict the resultant fallout debris field.

Disciplines which may advance the knowledge base for plasma chemistry for nuclear forensics include but are not limited to high temperature chemistry, physics, materials science, plasma physics, mathematics and statistics, computer science, and modeling and simulation.

Impact: An increased understanding of fireball plasma chemistry for nuclear forensics addresses DTRA's counter-WMD need to support attribution to those responsible for a nuclear attack, and improved response and recovery efforts. Such research has the potential to increase the accuracy of modeling and simulation for prediction of fallout plumes, leading to enhanced collection of debris for forensic analysis as well as protection of populated areas.

Objective: This topic seeks a greater understanding of the complex chemistry and physics taking place shortly after a nuclear detonation. Breakthrough methodologies are sought to enhance our understanding of plasma chemistry and related processes inherent in a nuclear event fireball, from blast to fallout (temperatures of 1 eV or lower). Specific interests include thermodynamics, kinetics, mixing of surface material, particle agglomeration, particle size distribution, plasma chemistry, dusty plasmas, and chemical speciation. White papers proposing research on nuclear weapons effects, nuclear weapons environments, and/or radionuclide environmental fate and transport are not a primary focus of this topic. Proposals that engage government laboratory institutions are permitted and encouraged.

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

- Thermodynamic properties
    - Henry's law constant for noble gases in matrices
    - Gibbs free energy

- Chemical kinetic properties
    - Effects of temperature
    - Effects of pressure
- Methods to quantify amounts of specific material entrained in detonation fireball
- Methods to quantify particle agglomeration, including rates, sizes, etc. at the various temperatures and pressures within the fireball
- Determination of chemical speciation of fireball condensates (e.g. hydrides, oxides, nitrides) and their formation kinetics

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PerF-YIP-Topic 1: Plasma Chemistry for Nuclear Forensics (Thrust Area 1)

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

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

PerF-Topic 2: Basic Research on Prompt Diagnostic Signatures of Nuclear Detonations for Forensics (Thrust 1)

Average Award Amounts for PerF-Topic 2:

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

Award Structure for PerF-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 research that may enable accurate knowledge of the specifics of a nuclear device (e.g., special nuclear material type and mass, device sophistication, etc.) after a detonation. Ideally this knowledge would be available in as short a time as possible with a high degree of confidence. The Defense Threat Reduction Agency is responsible for research and development that will enable an improvement in post-detonation technical nuclear forensics capabilities. This topic investigates basic physical research on the prompt signatures of nuclear explosive events, such as novel methods for yield determination, device reaction history, or the radiation outputs of these nuclear explosions. Research could focus on the understanding of unique identifiers of these explosions, measurements of these identifiers, or other topics. In this context, prompt signatures indicate those which can be measured instantaneously to within a few hours after the event. These signatures are generally separate from radiochemical signatures that may require multiple days to collect and analyze.

Impact: Research into the prompt signatures will enable rapid technical nuclear forensics supporting attribution. Knowing the specifics of a nuclear device (e.g., special nuclear material type and mass, device sophistication, etc.) in as short a time as possible, with a high degree of confidence, is the ultimate goal of technical nuclear forensics. Shortening the timeline for when knowledge becomes available could have a revolutionary impact on the technical nuclear forensics timeline. A full exploitation of the prompt diagnostics of the nuclear event has the potential to greatly reduce the attribution timeline because of the immediate nature of these important signatures.

Objective: This topic explores novel methods and techniques in the measurement and analysis of the prompt diagnostic signatures of nuclear explosions for forensics purposes. A specific interest is the investigation of the prompt signatures of nuclear explosive events, such as novel methods for yield determination, device reaction history, or the radiation outputs of these nuclear explosions.

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

- Investigation of methods to fuse multi-modal data to determine the explosive yield and reaction history of a nuclear event.
- Investigate absorption and attenuation of Teller light in complex environments
- Exploration of methods to measure the gamma ray spectrum of a nuclear event.
    - Investigation of techniques to account for scattering effects of radiation transport
- Novel techniques for determining information about the nuclear explosion from radiofrequency (RF) measurements.
    - Exploration of the use of RF bands to determine turbulence
- Investigation of optical properties of air for signal propagation, exploring reflection and attenuation coefficients as a function of air composition and frequency

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PerF-YIP-Topic 2: Basic Research on Prompt Diagnostic Signatures of Nuclear Detonations for Forensics (Thrust 1)

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

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

PerF-Topic 3: Radiation Effects in Wide Bandgap Semiconductor Materials (Thrust Area 3)

Average Award Amounts for PerF-Topic 3:

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

Award Structure for PerF-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: Ultra-wide bandgap and wide bandgap materials (WBMs, where E_g >3 eV) possess many physical properties which are superior to those of silicon (Si, ~1.1 eV) and gallium arsenide (GaAs, ~1.4 eV) for electronics application that require fast switching or power handling, including breakdown electric field, electron or hole mobility, and thermal conductivity. These improvements in material properties should enable improvements in the radio frequency (RF) electronics and power systems which incorporate them – notably in breakdown voltage, switching frequency, power efficiency, current density, and operating temperature.

WBMs also possess two other improvements over Si and GaAs–increased threshold displacement energies and electron-hole pair formation energies – which should enable an essential property for DoD-critical RF and power systems: greater radiation insensitivity. Certain critical systems must be able to operate in challenging radiation environments (both natural and manmade), and this ability is normally achieved through some combination of component derating (which effects performance), hardening techniques (which may be a significant expense in terms of time, weight, and cost), and monitoring methods (which shut down devices before permanent damage can occur).

Silicon carbide (SiC) and gallium-facing gallium nitride (GaN) are two wide bandgap materials whose development have resulted in improvements to the RF and power systems essential to the DoD. However, various SiC and GaN devices have also exhibited problematic radiation effects. For example, GaN-based devices which use high mobility two-dimensional electron gases may encounter band bending and mobility degradation caused by interface strain, charge trapping, or Frenkel defect formation. Radiation effects observed in SiC power devices include increased leakage currents, anomalous charge amplification, or regenerative currents which lead to breakdown. The current understanding is that these are the result of ion-induced impact ionizations at high voltage or low-resistance paths caused by interactions between recoil-induced defects and as-grown defects.

Concurrent with the significant investments and advances made in GaN and SiC, intense research in a collection of other WBMs (AlN, N-polar GaN, n-type diamond, β-Ga_2O_3 and other oxides) has accumulated sufficient knowledge of the fundamental physics which govern these materials and their growth processes to enable the low-defect growth of these materials. These materials offer additional enhancements over SiC and Ga-facing GaN, such as: even wider bandgaps, further improvements in physical and electrical properties, simpler growth processes, integration with silicon processes, and greater anticipated radiation hardness.

With as-grown defects sufficiently minimized, radiation effects in test devices that incorporate these wide bandgap material systems may now be comprehensively examined and understood at the basic research level.

Impact: Understanding the effects of radiation in these alternate WBMs may enable the development of radiation-insensitive wide bandgap devices for critical power and RF applications with fewer hindrances to fabrication, integration, or performance than SiC and Ga-polar GaN. WBMs which offer inherent radiation hardness from the start may mitigate the need for costly radiation hardening procedures later in the development cycle while enabling future devices to fully utilize the important improvements they offer over Si, GaAs, SiC, and GaN.

Objective: The objective of this topic is to understand the fundamental physics of radiation effects in wide bandgap and ultra-wide bandgap materials and devices with potential applications in RF generation and power switching. Total dose effects, displacement damage, and single event effects are of interest.

Possible wide bandgap and ultra-wide bandgap materials include, but are not limited to:

- N-face GaN
- β-Ga_2O_3
- c-Boron nitride
- Other wide bandgap oxides appropriate to RF and power devices
- Diamond
- AlN

This topic is **not** interested in materials or devices intended primarily for logic or memory applications. **Nor** is it focused on reducing the defects accrued during material growth.

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.

PerF-YIP-Topic 3: Radiation Effects in Wide Bandgap Semiconductor Materials (Thrust Area 3)

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

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

PerF-Topic 4: Radiation Effects in Non-Conventional Computing Approaches (Thrust Area 3)

Average Award Amounts for PerF-Topic 4:

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

Award Structure for PerF-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: Satellites and other critical DoD systems must operate in environments with high levels of natural radiation and survive the higher doses and dose rates of a manmade nuclear event. Traditionally the most vulnerable components, the digital computing microelectronics, have been protected by brute force hardening techniques. Digital computing, particularly using charge based devices in a traditional von Neumann architecture, is intrinsically susceptible to propagating errors and performance degradation caused by the effects of radiation. Traditional hardening of digital computing systems involves multiple hardening techniques including; material selection, process control, circuit design, layout optimization, triple redundancy, and software based error detection and correction. While these techniques have proven successful historically, they add cost, development time, complexity, and weight to critical systems. This traditional approach is further

challenged by the availability of commercial rad-hard parts and the business trends in commercial semiconductor foundaries.

Several alternative computational approaches are in development that may be more intrinsically radiation resistant than the classic digital approach. Some of these alternate approaches, such as neuromorphic computing, quantum computing, and optical computing are being developed for their ability to address hard computational problems, such as image recognition and cryptography, faster and more efficiently. Neuromorphic computing seeks to emulate the low power, highly interconnected, and highly parallel computational processes used by neurons in the brains of living systems. This computational approach may be able to inherently correct upsets or transients caused by high energy particles and adapt to shifts in device performance caused by charge accumulation or displacement damage. Quantum and optical computing approaches are still in the early stages of development and it is difficult to predict the development timeline and what a final implementation might look like. However, as non-conventional computational approaches, they may also be intrinsically resistant to single event effects and significant work has already been done on error correcting in quantum computing.

Impact: Non-conventional computational approaches have the potential to offer orders of magnitude improvements in computational power and efficiency, especially for computationally hard problems such as pattern or image recognition. These non-conventional computing approaches also have the potential to operate reliably in high radiation environments due to an intrinsic system level radiation effects resistance rather than requiring extensive hardening.

Objective: Investigate the effects of radiation (gamma, neutron, proton, and heavy ion) on non-conventional computational approaches. Effects caused by single high energy particle strikes, as well the cumulative effects caused by total ionizing dose and displacement damage are of interest. This topic is interested in understanding the device level and computational level effects of radiation on non-conventional computation approaches through investigations of the fundamental physics of radiation interaction combined with theory, modeling, and simulation. This topic **not** interested in developing or fabricating unconventional computational devices. Some development and testing of devices and logical approaches or computational frameworks may be necessary to better understand potential radiation effects.

PerF-YIP-Topic 4: Radiation Effects in Non-Conventional Computing Approaches (Thrust Area 3)

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

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

PerF-Topic 5: Bridging the Gap: From In Vitro to In Vivo Studies for Radiogenic Disease Risk Estimation (Thrust Area 3)

Average Award Amounts for PerF-Topic 5:

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

Award Structure for PerF-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: The U.S. military annually monitors 70,000 individuals, amounting to ~2% of its workforce, for occupational ionizing radiation exposure[1]. The DoD has the largest integrated radiation exposure of any federal agency (59% in 2006)[2] and has the potential for radiation exposure of its affiliated individuals during a nuclear or radiological event[3]. The U.S. military supports independent scientific studies to ascertain whether service members have experienced adverse health effects as a result of their radiation exposure[4], although determining the link between exposure events, cellular "initiating events", and development of latent disease states remains a challenge. In the absence of such knowledge, devising systematic approaches to prevent "after-battlefield" effects will be nontrivial. Gender-based differences compound the problem, as relative sensitivities to radiogenic disease development[5] may dictate use of more refined and individualized therapeutic approaches.

Current attempts to estimate radiogenic disease risks at doses between 0.1-1 Gy based upon epidemiological studies carry significant uncertainties, as demonstrated by the large standard errors associated with excess relative risk for virtually every exposure-correlated disease state[6]. The task of quantifying excess relative risk is problematic for many reasons related both to the general vagaries of properly parsing and interpreting epidemiological data and to the difficulties in determining the key cellular events that lead to adverse outcomes like radiocarcinogenesis[7,8]. The nature of the dose-response curve and defining thresholds at which deterministic versus stochastic events may predominate are hotly debated issues. Although increasingly more sophisticated approaches are being applied to the problem of epidemiological uncertainty, epidemiological studies alone are unlikely to yield desired information on cellular changes which probabilistically favor the development of radiogenic disease.

Instead, targeted research that evaluates informational content in existing studies and relevance of selected biological markers to disease initiation could be useful in teasing out causal relationships between cellular alterations resulting directly or indirectly from radiation exposure and whole animal responses. A wealth of *in vitro* and *in vivo* data is already available, thus it may be prudent to integrate and analyze those data before conducting additional laboratory studies, in order to make best use of available resources: "…circumstances require that we move away from an overdependence on in vivo testing and make greater use of computational…tools" in order to "minimize reliance on resource-intensive testing approaches[9]." Recent advances in the fields of bioinformatics and systems biology provide promise that computational approaches can be successfully applied to the present task.

Impact: Conducting the work described herein will help to identify initiation events and pathways for radiogenic disease at doses relevant to warfighter and C-WMD missions. The information can be used to make better use of available therapeutic interventions to combat latent diseases associated with radiation exposure and reduce "after battlefield" effects. As importantly, identification of trigger events characteristically associated with development of latent effects will enable likewise identification of targets for protection. Knowledge gained as a result of these studies can be applied to design of "smart" radioprotectants specifically tailored to prevent damage to identified cellular targets. The long-term benefit will manifest as reduced mortality and morbidity for the warfighter which will increase mission effectiveness as well as reduce long-term healthcare costs.

Objective: The overarching goal is to identify molecular targets whose perturbation acts as a primary initiating event for or significant contributing event to development of latent radiogenic disease. Moreover, synthesis of existent data is desirable in order to identify critical gaps in knowledge and provide an analytical framework to guide future studies. The present topic focuses in particular upon radiocarcinogenic phenomena and seeks

bioinformatics approaches which can convincingly reconcile data from *in vitro* and laboratory *in vivo* studies such that correlations between observed damage and response pathways in discrete cell lines and development of solid tumor cancers in [non-human] animal model systems can be elucidated. Proposed efforts should be purely computational and should make use of existent *in vitro* and *in vivo* datasets available in archives, literature, and unpublished studies where applicable. Studies designed to identify biomarkers or for development of radiobiology profiles to guide radiotherapy treatment regimens will not be considered.

The Life Span Study and others document the relative sensitivity differences between males and females with respect to development of bladder, lung, colon, stomach, and other solid tumor cancers, thus actuation pathways for such cancers are of particular interest. Applicants should focus on studies that evaluate effects of low-LET radiation doses within the range 0.1 – 1 Gy, where estimations of excess relative risk in exposed populations suggest linearity of the relationship between dose and response. Thyroid and blood cancers which deviate from the linear dose-response model, at least in the range indicated, are not desirable study endpoints for the work described herein. Consistency of dose rates among the studies evaluated should be sought, where possible. Proposals to interrogate biological effects outside of the specified dose range are not considered responsive.

Applicants should delineate and justify assumptions, including those associated with hypothetical cause-and-effect relationships between proposed indicators and outcomes. Likewise, ample rationale should be provided for selection of data types (e.g., biomarkers versus bioindicators, -omics changes versus gene amplification, and so on) and choice of model systems. Proposals should clearly establish that model systems are appropriate surrogates for warfighter populations. Competitive proposals will incorporate sensitivity analysis and risk mitigation plans, especially for cases where small changes to assumptions may result in large changes to end-state predictions. Proposals should explain methods that will be used or developed to quantify uncertainties.

References

1. Blake, P.K. and Komp, G.R. (2014) "Radiation Exposure of U.S. Military Individuals." *Health Physics* 106(2): 272-278. Ref: http://journals.lww.com/health-physics/Fulltext/2014/02000/Radiation_Exposure_of_U_S__Military_Individuals.17.aspx
2. NCRP (2009) *Ionizing radiation exposure of the population of the United States,* Bethesda, MD: National Council on Radiation Protection and Measurements; NCRP Report 160. Ref: http://www.ncrppublications.org/Reports/160
3. Cassata, J., Falo, G., Rademacher, S., Alleman, L., Rosser, C., Dunavant, J., Case, D., and Blake, P. (2012) "Radiation Doses for Shore-Based Individuals in Operation Tomodachi, Revision 1". DTRA-TR-12-001 (R1) Defense Threat Reduction Agency, Fort Belvoir, VA. Ref: https://registry.csd.disa.mil/registryWeb/Registry/OperationTomodachi/DisplayReferences.do
4. DTRA NTPR Program Factsheet (May 2015). Ref: http://www.dtra.mil/Portals/61/Documents/NTPR/NTPR%20Program%20-%202015.pdf
5. Gilbert, E.S. (2009) "Ionising radiation and cancer risks: what have we learned from epidemiology?" *International journal of radiation biology* 85(6): 467-482.
6. NAS/NRC (2006) *Health Risks from Exposure to Low Levels of Ionizing Radiation: Phase 2, BEIR VII,* National Academy of Sciences/National Research Council, Board on Radiation Effects Research, National Academies Press, Washington, DC. Ref: http://www.nap.edu/catalog/11340/health-risks-from-exposure-to-low-levels-of-ionizing-radiation
7. Shah, D.J., Sachs, R.K., and Wilson, D.J. (2012) "Radiation-induced cancer: a modern view." *The British Journal of Radiology* 85:e1166-e1173.
8. Preston, J.R. (2014) *Integrating Basic Biology and Epidemiology: Closing the Gap for Risk Assessment,* National Academy of Sciences - Planning Towards the BEIR VIII Report. Ref: http://dels.nas.edu/resources/static-assets/nrsb/miscellaneous/BEIRPreston.pdf
9. Ankley, G.T., et al. (2010) "Adverse outcome pathways: a conceptual framework to support ecotoxicology research and risk assessment." *Environmental Toxicology and Chemistry* 29(3):730-741.

PerF-YIP-Topic 5: Bridging the Gap: From In Vitro to In Vivo Studies for Radiogenic Disease Risk Estimation (Thrust Area 3)

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

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

PerF-Topic 6: Isotopic Discrimination using Biological Systems (Thrust Area 3)

Average Award Amounts for PerF-Topic 6:

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

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

Award Structure for PerF-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: DTRA is charged with providing for sustainment of operations in CBRNE environments. Detection of fissile material, which may be identified either directly or through characteristic fission products, is necessary to support this aim. Extant detection technologies require collection of material for off-site laboratory analysis, whereas on-site systems are relatively non-specific and require extensive logistical support. Biologically-based detection systems which can report the presence of specific isotopes characteristic of nuclear activity may provide an attractive alternative to conventional methods. Previous research has demonstrated the remarkable selectivity of biological systems for specific analytes at the exclusion or near-exclusion of others. Moreover, even when analyte is no longer present within the system, physiological changes resulting from exposure can persist and are detectable.

The present topic seeks novel solutions for detection and discrimination of signatures indicating proximity of nuclear processes, with a particular focus on use of indigenous biological systems for said purpose. Signatures are limited to isotopes indicative of nuclear fuel cycle or weapon development activity. The anticipated end-state capability is a reliable biosensor of radionuclide exposure or accumulation for use in environments characterized by low levels of contamination.

Exposure to ionizing radiation (IR) is characterized by genetic mutations, modifications to cellular pathways and associated –omics expression patterns[1,2] , structural alterations[3,4], and organellular dysfunction[5,6]. Organismal response to low dose irradiation is different from that of high dose exposure, thus simple extrapolation from the well-defined effects consequential to high doses is not expected to be predictive of changes induced by low level exposures. Further, the quality or linear energy transfer (LET) of the radiation can alter the radiation response[7]. High-dose IR will, among other effects, damage DNA and elicit a damage response that activates repair[8]. Low dose radiation (LDR), defined here as < 0.1 Gy, will elicit responses such as an adaptive response (AR), genomic instability, hypersensitivity, and the bystander effect. Ultrastructural changes to organelles such as the mitochondria[5] and lysosomes[6] may be correlated with observed effects and could prove useful as proxy indicators of exposure. However, the hypothetical mechanisms by which they contribute to cellular damage have yet to be experimentally validated. LDR responses have been shown to include phenotypic modifications driven by processes such as DNA methylation, histone modification, and expression of noncoding RNAs such as microRNAs (miRNAs) and ling noncoding RNAs (lncRNAs)[7,9]. Additionally, LDR has been shown to induce changes in DNA methylation that are tissue specific and exhibit dose and time dependence[8]. Such modifications may also result from exposure to other toxicants, such as heavy metals[10]. Recent work has demonstrated that microbial communities characteristically exhibit specific protein isoforms in the presence of Pb, as in uranium mine tailings[1], and preferentially produce certain types of porphyrins following UVB exposure[4], although dose- and isotopic-dependencies have not been further investigated for these markers.

Taken together, the aforementioned results suggest that identifying biological profiles indicative of internal or external exposure to a specific radionuclide or distinguishing among exposures to different isotopes of a particular element is possible. The research described herein is designed to establish, characterize, and determine the stability and consistency of profiles resulting from exposure to selected radionuclides of interest.

Impact: The fundamental knowledge generated as a result of these research efforts 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 radionuclide exposure profiles in organisms will provide the baseline understanding necessary to engineer field detection technologies in response to novel and emerging threats. Finally, the development of radionuclide detection 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 determine the feasibility of characterizing measurable biological responses that are specific to a mode and level of energy transfer to the cell (alpha, beta, gamma, and neutron) and can differentiate among elemental sources. Interrogation of micro- and macro-organisms is acceptable, provided the organisms are either ubiquitously distributed or, if indigenous, expected to be present in some abundance in ecosystems of interest. Geographical ranges for selected organisms should be limited and/or well-defined. Research efforts should focus on sentinel organisms for which a reasonable amount of biological information is available, and life cycles of either populations or individuals (dependent upon model system) should be compatible with periodicity of contamination events. Appropriate model systems are those which have a high likelihood of exposure to radiation as a result of their natural ecologies.

Both discriminatory power and persistence of biological signal should be evaluated. Biological signals are broadly described as "organismal responses" in the background section but may include others, provided there is literature precedent that provides reasonable expectation of utility for the present purpose. Proposed studies should include necessary controls to validate specificity of response to radiation as opposed to other toxicants (e.g., heavy metals) or endogenous / exogenous conditions that could instigate similar responses.

Relevant elements and isotopes, as well as environmental fates and chemistries which would dictate biological availability, should be established by reviewing standard nuclear engineering texts and other documents. Competitive submissions will demonstrate that both levels of exposure and forms of the elements and isotopes being investigated are reasonably anticipated to be correlated with likely releases and release amounts for nuclear processes of interest. Useful signatures are those uniquely relatable to processes of interest and for which little or no background signal is anticipated to be present. Preliminary research can establish proof-of-concept for biological response, but option year plans should propose means to establish that limits of detection are congruent with expected environmental level(s) for a given analyte.

References

1. Solobev S, Begonia MFT. Effects of Heavy Metal Contamination upon Soil Microbes: Lead-induced Changes in General and Denitrifying Microbial Communities as Evidenced by Molecular Markers. International Journal of Environmental Research and Public Health 5, 450-456 (2008)
2. Stickel S, Gomes N, Su TT. The Role of Translational Regulation in Survival after Radiation Damage; an Opportunity for Proteomics Analysis. Proteomes 2, 272-290 (2014)
3. Carugo O, Carugo KD. When X-rays Modify the Protein Structure: Radiation Damage at Work. Trends in Biochemical Sciences 30, 213-219 (2005)
4. Wang Y, Zhu W, Shu M, Jiang Y, Gallo RL, Liu Y-T, Huang C-M. The Response of Human Skin Commensal Bacteria as a Reflection of UV Radiation: UV-B Decreases Porphyrin Production. PLOS ONE 7:10, 1-11 (2012)
5. Szumiel I. Ionizing Radiation-Induced Oxidative Stress, Epigenetic Changes and Genomic Instability: The Pivotal Role of Mitochondria. International Journal of Radiation Biology 91, 1-12 (2015)
6. Bright S, Fletcher AG, Fell D, Kadhim M. Evidence of a Role for Radiation-Induced Lysosomal Damage in Non-targeted Effects: An Experimental and Theoretical Analysis. bioRXiv < http://dx.doi.org/10.1101/024661> (2015)
7. Kabacik S, Manning G, Raffy C, Fouffler S, and Badie C. Time, Dose and Ataxia Telangiectasia Mutated (ATM) Status Dependency of Coding and Noncoding RNA Expression after Ionizing Radiation Exposure. Radiation Research 183, 325-337 (2015)
8. Lima F, Ding D, Goetz W, Yang A, and Blauch J. High LET 56Fe Ion Irradiation Induces Tissue-Specific Changes in DNA Methylation in the Mouse. Environmental and Molecular Mutagenesis 55, 266-277 (2014)
9. Rashi-Elkeles S, Warnatz H, Elkon R, Kupershtein A, Chobod Y, Paz A, Amstislavskiy V, Sultan M, Safer H, Nietfeld W, Lehrach H, Shamir R, Yaspo M, Shiloh Y. Parallel Profiling of the Transcriptome, Cistrome, and Epigenome in the Cellular Response to Ionizing Radiation. Science Signaling 7 (253), rs3. [doi: 10.1126/scisignal.2005032]

10. Ye S, Yuan D, Xie Y, Pan Y, Shao C. Role of DNA methylation in the adaptive responses induced in a human B lymphoblast cell line by long-term low-dose exposures to ɣ-rays and cadmium. Mutation Research 773, 34-38. (2014)

PerF-YIP-Topic 6: Isotopic Discrimination using Biological Systems (Thrust Area 3)

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

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

PerF-Topic 7: Dynamic Characterization of Post-Detonation Fireballs Involving Agent Defeat Additives and Agent Simulants (Thrust Area 4)

Average Award Amounts for PerF-Topic 7:

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

Award Structure for PerF-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: Prompt counter-WMD operations in non-permissive or access-denied environments often require energetics to effectively defeat a target (i.e., those containing WMD targets with biological and chemical agents). 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. Characterization capabilities are needed to assess the confidence in immediate lethality of a weapon formulation against an agent and potential longer term viability of the threat. There is a great need to develop next-generation diagnostic techniques to effectively characterize the physical and chemical processes occurring during rapid combustion in an expanding fireball, particularly those interacting with WMD agent. Challenges for rapid diagnosis include optical thickness of the associated fireball (approaching 5-6 logs) and harsh pressure and temperature environments that may damage equipment in or near the fireball.

New techniques utilizing both novel materials and sources for measuring interactions of weapons with WMD targets containing viable agents are highly desired. Both spatially resolved measurements and standoff measurements may offer additional insight into these interactions. Dynamic characterization will provide information for modeling and simulation efforts, from microseconds to seconds of the expanding fireball. Key parameters of interest include species concentrations, chemical identification and temperature field. Newly developed techniques would initially be applied to agent simulants. Innovative use of the combination of coherent or quasi-coherent photons, material science, and modeling may allow reconstruction of the spatiotemporal evolution of post blast field involving CWMD weapon additives and agent simulants.

Impact: The immediate potential payoff of these research efforts is expected to be the development of dynamic characterization techniques that will enable the ability to measure parameters such as agent species and concentration which will vastly improve blast and weapon modeling. The primary focus would be to extract the species and concentration data. Knowledge of species and concentrations as a function of space and time are critical for predicting a weapon's effectiveness and lethality against chemical-agent containing WMD targets. Other parameters such as localized time-dependent temperature inside the fireball may be simultaneously measurable using these new techniques. Previous investments in temperature sensors provided limited temporal information. With the new techniques being sought, more critical temporal data may be feasible. The optimization of these tools will result in better designed agent defeat weapons that can achieve higher agent lethality. This will improve weapon and target planning for defeat of WMDs containing chemical weapon agents, reduce or eliminate collateral effects and enhance post-strike assessments, in all attempts to successfully destroy WMD in hostile environments.

Objectives: The objective of this topic is to support basic research in characterizing the extreme environment of an emerging fireball containing agent defeat additives interacting with chemical agent simulants. There is a lot of interest in the ability to increase pulsed probing rates significantly beyond kHz (toward MHz). Primarily, interest is in tracking the evolution of key species and concentrations of weapon additives and simulants within the fireball; however, innovative approaches looking at regions slightly removed from the most optically dense region may also be considered.

Characterization capabilities may include, but are not limited to:

- Identify and measure species concentrations using absorbance beyond kHz repetition rates
- Photoacoustic techniques appropriate for highly transient environments
- Linear and nonlinear optical techniques appropriate for characterizing species and species concentrations within high optical thickness environments (approaching 5-6 logs signal reduction)
    - Enabling research on optical sources and transport materials for probing key spectral regimes (e.g. fingerprint region of simulants)
- Reconstruction of temporally resolved temperature fields in and around the blast of the energetic material and simulant
- Post-blast material analysis and model validation to support spatiotemporal fireball characterization

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PerF-YIP-Topic 7: Dynamic Characterization of Post-Detonation Fireballs Involving Agent Defeat Additives and Agent Simulants (Thrust Area 4)

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

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

PerF-Topic 8: Photochemistry of Organohalides and Agent Simulants (Thrust Area 4)

Average Award Amounts for PerF-Topic 8:

- Single Scope Awards will average approximately $100,000 to $150,000 per year.
- Multidisciplinary Awards will average approximately $200,000 to $300,000 per year.

Award Structure for PerF-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: Prompt defeat of agents relies heavily upon energetic systems creating conditions for thermal decomposition or chemically generated reaction pathways, both leading to defeat of the agent. This topic is intended to investigate mechanisms generated via controlled interaction between optical frequencies and energetic systems containing organohalide molecules and other additives (metals and oxides). The ability to control reactions involving organohalide molecules may lead to enhancements in desired performance for agent defeat.

Current laser technologies offer great potential for highly controllable optoelectronic interactions with molecules. Controllable laser parameters include wavelength, intensity, phase control, etc. Lasers offer the ability for controlled decomposition of organohalide molecules and chemical agent simulants. We desire to understand the limits of photo induced control for decomposition and reactions involving potential additives and agent simulants. Better understanding of these photo-controlled processes may lead to new understanding of potential reaction pathways and formation of possible toxic intermediates/products.

Impact: Prompt defeat of agents is typically carried out in access denied environments through traditional energetics and is challenging to control the reaction mechanisms and energy release rate. This work may demonstrate the viability of controllable mechanisms involving optical fields and small scale energetics and agents. This effort work may lead to knowledge resulting in increased lethality against viable agents.

Objectives: The objective of this topic is to support basic research using coherent photons to control the decomposition pathways of organohalide molecules and those interacting with organophosphorous agent simulants and coated spore simulants. We want to identify conditions for molecular decomposition of organophosphorous agent simulants. We are primarily interested in experimental efforts, but will consider complementary theoretical/computational efforts.

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

- Photocontrol of reaction mechanisms for decomposition of organohalides
- Photo induced interactions of organohalides with organophosphorous simulants
- Optical interactions involving additives (such metals and oxides) with simulants
- Nonlinear optical interactions directly with agent simulants (i.e. organophosphorous molecules and coated spore simulants)

PerF-YIP-Topic 8: Photochemistry of Organohalides and Agent Simulants (Thrust Area 4)

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

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

PerF-Topic 9: Novel Signatures and Methodologies to Monitor Very Low Yield Explosions (Thrust Area 5)

Average Award Amounts for PerF-Topic 9:

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

Award Structure for PerF-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: Monitoring technologies are noted for their importance to support nuclear arms control and nonproliferation, and to assure compliance with current and future nuclear weapon related treaties/agreements. Countering future weapons proliferation should go beyond current treaty approaches to the problem. It is important to conduct basic research to significantly improve existing approaches, or to identify and understand novel approaches, in order to identify very low yield events that are difficult to observe under traditional international sensor networks. Recent events and historical trends serve to emphasize the continuing need for improvements in nuclear test monitoring because of continued nuclear testing. Seismic methods provide a major means of detecting and characterizing underground explosions. These methods can be augmented by other techniques; e.g., infrasound, hydroacoustic, or radionuclide networks. Sensing and characterization of suspected nuclear events may involve additional signatures or approaches than those of traditional monitoring systems. For example, there may be environmental factors near an underground explosion that are disturbed. Alternatively, truly novel advances in seismic methods beyond traditional approaches may enable game changing capability in monitoring.

Basic research into observable phenomena may yield novel means for understanding events that represent potential nuclear explosions. Basic research into observable phenomena may yield novel means for understanding events that represent potential nuclear explosions. The Comprehensive Nuclear Test-Ban Treaty is a ban on nuclear explosive testing (http://www.state.gov/t/avc/c42328.htm). Publications and presentations on the detection of very low yield seismic events discuss current progress in basic science methods. For example, research teams have reported ability to detect and analyze seismic events as small as magnitude ~ 1.5 in one case. A publication by Miao Zhang and Lianxing Wen claimed analytic ability to detect a very small event ("Seismological Evidence for a Low-Yield Nuclear Test on 12 May 2010 in North Korea", Seismological Research Letters Volume 86, Number 1 January/February 2015; doi: 10.1785/02201401170). Subsequently, a separate analysis was presented by Paul Richards which addressed this report ("A Seismic Event in North Korea on 12 May 2010 – Claims, supporting evidence, and some discussion for a CTBT-relevant event", CTBT: Science and Technology Conference 2015 Conference, Vienna, Austria, June 2015). It is desirable to continue to push the limits of detection as far as possible and significantly enhance measurement methods for yield approaching as close as possible to zero in support of future international monitoring.

Impact: Advancements in fundamental science may foster future technologies that extend both the lower limits and reliability of yield determination; help discriminate between nuclear and non-nuclear events that may be confused with nuclear explosions; and support countering proliferation of nuclear weapons capability. Success in this research will lead to ability to monitor explosions beyond the capability of the current international networks.

Objective: The objectives of this topic are to identify and explore novel approaches to explosion monitoring in order to observe event yields below 1 kiloton equivalent yield, and push the measurement as low as possible toward zero to better advance discrimination globally.

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

- Conducting theoretical, computational, or experimental studies to significantly improve understanding of geological factors that affect phenomena (i.e., non- seismic particle or energy transport as well as seismic propagation) near the energy source of an event.
- Advancing the body of basic knowledge of seismic signal generation or propagation in the source region of events for extending measurement to as low as possible in yield determination; and, quantitative predictions of transformation of signals from the source to far term propagation.
- Exploring non-seismic approaches to very low yield detection and measurement.

PerF-YIP-Topic 9: Novel Signatures and Methodologies to Monitor Very Low Yield Explosions (Thrust Area 5)

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

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