DEFENSE THREAT REDUCTION AGENCY

BROAD AGENCY ANNOUNCEMENT

HDTRA1-11-16-BRCWMD-Service Call for

DoD Degree-Granting Academic Institutions

Amendment 2 (December 2012)

Research and Development Enterprise

Basic and Applied Sciences Directorate

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

March 2011

TABLE OF CONTENTS

SECTION NO. **PAGE NO.**

1. INTRODUCTION AND SCOPE 3
2. PURPOSE AND RESEARCH TOPICS 3
3. AWARD INFORMATION 5
4. ELIGIBILITY 7
5. SUBMISSION INFORMATION 7
6. SUBMISSION DATES AND TIMES 17
7. APPLICATION REVIEW INFORMATION 19
8. AWARD & NOTIFICATION INFORMATION 21
9. AGENCY CONTACTS 22
10. PERIOD C TOPICS 23

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

[1] DoDI 3210.1, September 16, 2005

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

subsequent generation of information that provides knowledge of the presence, identity, and/or quantity of material or energy in the environment that may be significant.

- ***Thrust Area 2—Cognitive and Information Science:*** The basic science of cognitive and information 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 C, DTRA seeks unclassified, basic research ideas that are responsive to the goals and objectives of the topics outlined in Section 10. The topics labeled "PerC" are only valid for Period C of this Service Call. Only white papers responsive to the topics posted for Period C and submitted by the Period C 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.

3.1.1. 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

3.2. 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.

  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.

- 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.

3.3. 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.

3.4. Sub-contracts are permitted. Sub-contracts may be used to carry out a portion of the research. DTRA will review and consider the proposed sub-contracts 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.

3.5. Funding Restrictions. Indirect costs may be restricted to less than 35% of the total award value. The 2008 DoD Appropriations Act (Public Law 110-116, Section 8115), 2009 DoD Appropriations Act (Public Law 110-329, Section 8109), and the 2010 DoD Appropriations Act (Public Law 111-118, Section 8101) applied this restriction to awards made using fiscal year 2008, 2009, and 2010 Basic Research funds. This restriction does not apply to awards made using fiscal year 2011 and 2012 Basic Research funds but **may** apply to future awards.

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

3.7. 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 C 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. The final submission must be 'locked' on the DTRA proposal submission website; until a submission has been 'locked' (saved as final), the submission is not eligible for review. Look for this 'lock' icon  on the DTRA proposal submission website. Applicants are responsible for ensuring compliant and final locked 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 9.0 or earlier. Files must not exceed 2 Megabytes of storage space (uncompressed). Movie and sound file attachments or other additional files will not be accepted. Perform a virus check before uploading proposal files. If a virus is detected, it may cause rejection of the file. Uploaded files must not be password protected or encrypted.

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 C 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).

- 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 9.0 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.
- 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

[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 year 2011and 2012 Basic Research funds but may apply to future awards.

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[4]

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.

[4] 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 year 2011and 2012 Basic Research funds but may apply to future awards.

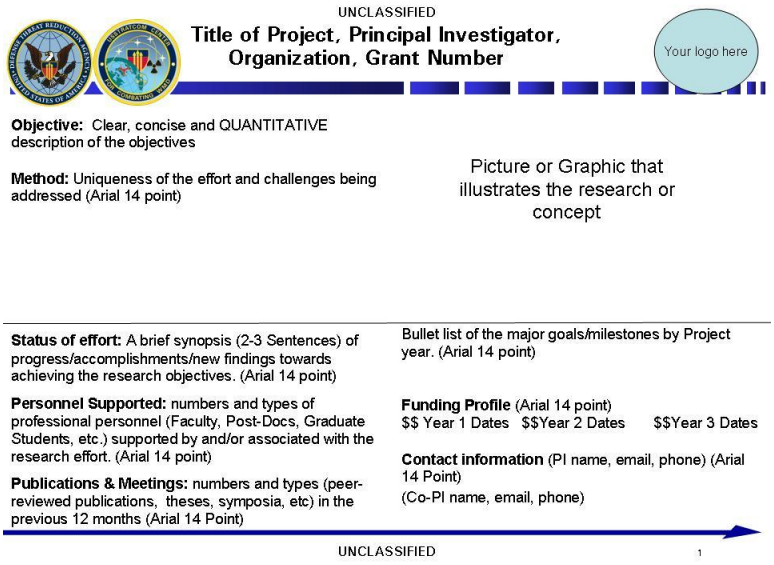

Figure 1: Pictorial representation of the quad chart.

SOW: SOW does not have a page limit, but should be approximately 3-5 pages in length for incorporation into award. 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 September of each year. Awards effective after 31 May will not require a progress report until 1 September of the following year. A Technical Reporting Guide may be found online at the www.dtrasubmission.net/portal.

  - □ Annual Quad Chart(s)

  - □ Annual Research Summary(ies): The Research Summary is a short (less than one page) description of the research objectives and current status.

  - □ Annual Metrics Survey

  - □ 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 using DD Form 882 Reporting 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.

  - □ The Federal Financial Report, SF425 is due annually, no later than 30 days after the end

of the reporting period for all awards. The reporting period shall be from 1 July– 30 June. First year reports shall have a reporting period of the start date of the MIPR through 30 June. Final reports shall be submitted no later than 90 days after the project or MIPR period end date. Applicants should note that Section 11 of the SF425 "Indirect Expense" must be completely in its entirety.

5.5. 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.

5.5.1. Export Control Notification. Applicants are responsible for ensuring compliance with any export control laws and regulations that may be applicable to the export of and foreign access to their proposed 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).

5.5.2. 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 not be reviewed 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	

CLOSED	
~~2:00 PM EST, 8 April 2011~~	~~Phase I white paper receipt deadline~~
~~September 2011 – March 2012~~	~~Period A awards~~
~~January – March 2012~~	~~Period A MIPRs scheduled to be awarded~~
Period B	
CLOSED	
~~1 December 2011~~	~~Amendment to the Service Call announced on www.dtrasubmission.net/portal with Period B topics and white paper receipt deadline~~
~~2:00 PM EST, Not prior to 2 April 2012, and not later than 20 April 2012 *~~	~~Phase II invitation-only proposal receipt deadline~~ ~~* The exact due date for the full proposals will provided in the letters of invitation~~
~~2:00 PM EST, 13 January 2012~~	~~Phase I white paper receipt deadline~~
October—December 2012	Period B MIPRs scheduled to be awarded
Period C	
3 December 2012	Amendment to the Service Call announced on www.dtrasubmission.net/portal with Period C topics and white paper receipt deadline
Midnight (11:59 PM) EST, 14 January 2013	Phase I white paper receipt deadline
Midnight EST, Not prior to 5 April 2013, and not later than 3 May 2013*	*The exact due date and time for the full proposals will be provided in the letters of invitation
October—December 2013	Period C MIPRs scheduled to be awarded
Period D	
TBD	Amendment to the Service Call announced on www.dtrasubmission.net/portal with Period C topics and white paper receipt deadline
TBD	Phase I white paper receipt deadline
TBD	Phase II invitation-only proposal receipt deadline
TBD	Period D MIPRs scheduled to be awarded
Period E	
Period F	

Period G
Period H
……
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 not be considered. Exceptions will not be considered.

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: TASC Inc. (advisory and assistance services) and their subcontractors, Suntiva Executive Consulting (contract specialist support) and their subcontractors, BRTRC Inc., SBG Technology Solutions, and Terremark Worldwide Inc. Each contract contains organizational conflict of interest provisions and/or includes contractual requirements for non-disclosure of proprietary contractor information or data/software marked with restrictive legends.

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.

7.3.5. 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@dtra.mil.

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

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: BRCWMD-TA1@dtra.mil

Thrust Area 2: BRCWMD-TA2@dtra.mil

Thrust Area 3: BRCWMD-TA3@dtra.mil

Thrust Area 4: BRCWMD-TA4@dtra.mil

Thrust Area 5: BRCWMD-TA5@dtra.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 C Topics

PerC-Topic 1: Manipulating Multiple Domains of the Electromagnetic Spectrum for Sensing Nuclear Materials in Complex Environments (Thrust Area 1)

Average Award Amounts for PerC-Topic 1:
- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerC-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: Conventional methods for the detection of nuclear signatures are limited by many obstacles which ultimately reduce their effectiveness at large distances. This topic explores novel methods and advancements in the ability to remotely sense alternative signatures of nuclear materials. In particular, this topic promotes the necessity of understanding the interactions between alternate signatures associated with nuclear materials and the surrounding environment or emitting material. This may include interferences from shielding materials or from large background sources. Advances in research exploring these novel methods may lead to an ability of sensing nuclear material remotely, with high signal to noise ratios, and at longer ranges (>100 meters).

For example, the advent of nonlinear optical science has made available a wealth of investigative techniques for various fields such as materials science and biological imaging, promising great capabilities in detection of alternative signatures. Even with this high-intensity laser technology, there are complexities that deter some techniques from being used in complex and dynamic

environments. Long stand-off distances for source generation and detection, air breakdown, and direct line-of-sight place limits on detection capabilities of nuclear materials. In general, local factors, such as humidity and atmospheric absorption, may also hinder certain regions of the electromagnetic spectrum from being used.

Basic understanding of physical mechanisms to enhance the specific signatures in nuclear materials in complex environments is critical to advancing the current state of the art. Formation of short-lived optical components at long distances may create advances in spectral and spatial distribution for signal enhancement. Observing and manipulating the temporal domain of material response for signal enhancement of alternative signatures to nuclear components is of particular interest.

Impact: Truly novel methods of manipulating light interactions with matter may transform detection techniques for nuclear materials and related secondary signatures. This topic is important to the counter-WMD mission of DTRA by addressing the need to extend detection of fissile materials and nuclear weapons to distances beyond current short-range capabilities. Developing novel detection methods could lead to the ability to sense shielded nuclear material.

Objective: Leveraging the entire electromagnetic spectrum (excluding γ's) and various time scales of nuclear and atomic processes may increase detection capabilities for the warfighter. Collaboration across multiple disciplines is strongly encouraged in order to successfully tackle some of the scientific challenges associated with this scale of work. Investigations may include, but shall not be solely limited to methods utilizing ionization mechanisms and fluorescence detection of the primary component of air (N_2). Limited consideration will be given to studies utilizing THz detection and filamentation, but must adequately address the unique challenges related to nuclear material detection.

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

- Investigate alternative signatures of nuclear and secondary materials in complex environments using the following examples of techniques or others not listed:
  - Laser matter interactions and/or detection mechanisms in or near nuclear environments
  - Ionized air molecules with a vetoed singlet-oxygen background
  - Cold-atom gravity gradiometry
- Exploration of one or more of the following aspects of alternate-signature detection methods:
  - Manipulate multiple domains (spatial, temporal and spectral) of an electromagnetic wave to probe the complex environment in close proximity to nuclear materials
  - Demonstrate understanding of mechanisms of light-matter interactions to enhance response of low level alternative signatures
  - Novel means for sensing air fluorescence from the interaction of radiation with the environment
  - Consider quantum effects including coherent control
  - Increase detection sensitivity via perturbation of local environments

PerC-YIP-Topic 1: Manipulating Multiple Domains of the Electromagnetic Spectrum for Sensing Nuclear Materials in Complex Environments (Thrust Area 1)

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

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

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

Average Award Amounts for PerC-Topic 2:

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

Award Structure for PerC-Topic 2:

- Will predominately be for a base period of three (3) years with up to two (2) additional years as possible options.
- Pre-application white papers and proposals that outline scope and effort for only the base period and do not propose options are also acceptable.
- Pre-application white papers and proposals that outline scope and effort for different base period and option combinations may also be considered. See Section II.1.1 for details on the possible structure of awards under this BAA.
- Note that pre-application white papers and proposals that outline scope and effort that exceed a total of five (5) years will not be considered.

Background: This topic explores ways to enable accurate post-detonation analysis of debris from a nuclear event on a short time scale. The Department of Defense provides the capability to collect and analyze post-detonation debris. DTRA is responsible for research and development that will enable this post-detonation forensics. The current methodology includes a radiochemical assay that requires time to obtain statistically accurate results. The advancement of analytical techniques could lead to the ability to accurately analyze debris on time scales shorter than this current methodology. Of interest are innovations that identify and quantify elemental and isotopic constituents of a fresh radioactive fallout debris sample. Of particular interest are accurate and timely measurements of major, minor, and trace constituents, including actinide species. Ideally, novel methodologies to perform these measurements would be field-adaptable and non-destructive, allowing for additional confirmation analysis on the same sample. Furthermore, improvement within the capability of sample collection is needed; novel methods are sought which have the potential for greater robustness under a wider variety of adverse conditions. Combining novel collection and analysis techniques is of interest where the analysis provides either identification or quantitative isotopic composition of the debris. Other areas of interest include understanding phenomenology that govern novel analysis methodologies, methodologies for compiling, assessing, and interpreting large sets of data, as well as understanding the treatment of data uncertainties. Disciplines which may advance the science for post-detonation nuclear forensics include but are not limited to chemistry, nuclear physics and engineering, materials science, instrument development, mathematics and statistics, computer science and modeling and simulation.

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

Objective: This topic explores novel methods and advancements in the ability to collect samples of material, analyze radioactive debris, and identify signatures from debris analysis in a post-detonation environment. Specific interests include the investigation of non-destructive analytical techniques, fundamental phenomenology of analytical measurements, and innovative data-set handling. Proposals that engage government laboratory institutions are also encouraged.

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

- Novel methods that enable rapid and cost-effective isotopic identification and measurement after a nuclear or radiological detonation
- Field-adaptable analytical techniques
  - Non-destructive methodologies are preferred
- Mathematical and statistical treatment methods of large, complex data sets relevant to radiological analyses
- Investigation of techniques with the potential to eliminate the need for time-consuming separative radiochemistry on a gross vs. net timeline
  - Techniques that reduce the overall timeline are preferred over techniques that have a short timeline but require multiple measurements, lengthy calibration procedures, etc.
- New scientific understanding of the phenomenology of techniques such as laser spectroscopy, mass spectrometry, and associated ionization methods
  - Insight via modeling or experimental methods into how the above techniques enhance counter-WMD science is encouraged over development of or improvements to instrumentation
- Investigations to improve databases of physical constants and their uncertainties
  - Constants such as cross sections, decay branching ratios, or nuclear energy levels relevant to nuclear forensic analysis
- Techniques or methodologies for repetitively validating and verifying measurements made on samples that have components inherently disappearing and changing with time.
- New methods for sample collection after a nuclear or radiological attack. Includes:
  - Airborne and ground collection methods
  - Combined collection and analysis methods
- Advanced methods of sample pre-concentration for higher signal output
- Exploration of methods with the potential to enable remote characterization and quantification of airborne debris

---

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

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

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

PerC-Topic 3: Nanoscale Solutions for Radiation Sensing Systems (Thrust Area 1)

Average Award Amounts for PerC-Topic 3:
- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerC-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: This topic seeks investigations which extend beyond the simple geometric scaling down of macroscale methods/materials by exploring nanoscale phenomenology and its potential impact upon an *entire system* for sensing and recognizing radiation from nuclear materials. Fundamental studies of the interaction of matter and mechanisms of transfer of energy are critical for successful development of nuclear sensing methodologies within the nanoscale regime as well as its viability as replacements for currently deployed technologies. Viability could be described to include the following: expense of nanomaterial, ease of mass production, ruggedness, "plug-and-play" functionality, etc. Highly viable nanomaterials would be those which have the potential to be mass-produced at a low cost for replacement of the more expensive materials presently used in radiation detectors, while maintaining or exceeding current detection capabilities (i.e. novel photodetectors as alternatives for the much older technology of photomultiplier tubes). Previous research in this topic area has shown that scintillators as well as semi-conductor sensors incorporating nanoparticles can lead to viable radiation detectors. Furthermore, previous research has shown that a detailed strategy for how to address the common problem of agglomeration of nanoparticles is essential for a successful project.

Impact: This topic is important to the counter-WMD mission of DTRA by revolutionizing point detection technology via the unique properties of nanomaterials that could provide unparalleled sensitivity and specificity.

Objective: Understanding nanoscale phenomenology is conducive to opening up new insight into possible applications for parts of the entire radiation sensing system, including novel sensor

materials and alternative methods for photon or electron multiplication. It is desirable for the principal investigator(s) to form collaborations with experts in the areas of the interactions of radiation with matter or radiological and nuclear material sensing.

Some of the research areas may include (but are not limited to):

- Exploration of nanoscale and nanostructured phenomenology
  - Interaction phenomena of primary and secondary radiations with nanomaterials resulting in conversion of radiation to observable signatures
  - Assemblies of repetitive nanostructures for bulk detectors of penetrating radiation
  - Properties of nanodevices and nanomaterials that enable micro-electromechanical systems for detection, characterization, and counting of radiation
- Nanostructured materials to be incorporated into room-temperature radiation sensors with excellent energy resolution
  - Innovative use of nanomaterials to provide novel mechanism of charge production transport and collection resulting from interaction with ionizing radiation
  - Novel detection of unique or ancillary signatures of fissile or radiological materials or the facilities in which they may be handled
- Investigation of compact, photosensitive solid-state sensors that may have the desirable properties of low-noise, fast response, and high quantum efficiency for the wavelengths that are commonly emitted by scintillators
- Flexible-nanostructured radiation sensors providing real-time dose reconstruction (nanomaterial dosimeter alternative)

PerC-YIP-Topic 3: Nanoscale Solutions for Radiation Sensing Systems (Thrust Area 1)

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

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

PerC-Topic 4: Understanding Multi-layer/Multi-dependent Network Responses to WMD Attacks and Developing Control Strategies for Cascading Failures (Thrust Area 2)

Average Award Amounts for PerC-Topic 4:
- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerC-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: In order to preserve essential military capabilities following an attack employing weapons of mass destruction (WMD), one must be able to predict the interdependent responses of the multiple interdependent military and national infrastructure networks that define the military capability in response to damage and to changes in network demand that result from such an attack. These include military networks (US and coalition), like the defense strategic communications system, global information grid (GIG) and battlespace networks; non-military networks, the national power grid and transportation grids. Critical considerations in the face of WMD disruption are network availability, interoperability, robustness and recovery. The basic nature of a WMD attack is that multiple nodes will be compromised simultaneously to varying degrees through a multitude of failure mechanisms – some common mode, others implementation-specific, still others as a result of dependencies. The space- and time-correlated details of the damage and the specific nature of the faulty behavior are not known a priori. The WMD stressors to networks can include, for example, widely distributed failures of electronics from nuclear electromagnetic pulse or the long-term denial of network elements or segments due to WMD contamination from nuclear, biological, and chemical (NBC) material as well as direct physical damage. Many current management approaches and policies of network systems contain static assumptions about the structure of network, and they do not account for time dependent variation in traffic type, significant changes in the number of operating nodes, dynamic interdependencies on other networks, changing security conditions and user demands, including the potential need to prioritize network traffic. In order to understand the critical vulnerabilities and develop avoidance/recovery strategies of such diverse, yet interdependent networks to WMD attack, a fundamental understanding of the approaches which capture network dynamics is required. This effort is intended to answer questions such as: What are the essential elements of any network? How do different implementations impact on interoperability, vulnerability, survivability and recovery of networks in a WMD environment? What is the mix of implementations that optimize these measures? What data would be most valuable to collect from existing networks to supplement/validate the mathematical and statistical models that will be developed under this effort? What are adaptive network policies and optimization methods? What are routing approaches for networks with variable connectivity and information content? What policies are suitable for managing user demand in the event of major attacks? How do failures in one networks spread to dependent networks and how can this cascading failure be managed?

Impact: This research will advance theoretical understanding and methods necessary to improve multi-layer/multi-dependent network robustness, management and recovery, and resilience to cascading failures. Understanding the fundamental properties that contribute to the robustness of multi-layer networks will support system reliability, survivability and security. This research will identify methods to use indirect information (e.g. peacetime performance indicators or network outages from natural events) for determining what data and how much data are needed to adequately understand the impact of WMD stressors on complex multi-layer networks. This will impact many areas such as sensor networks, telecommunications, and systems of systems. Defense systems and operating procedures can be optimized to ensure the maintenance of capabilities rather than individual systems, reducing acquisition costs and increasing WMD survivability and operability.

Objective: A prime objective of this effort is to develop mathematical, statistical, and analytical techniques to understand and represent dynamics and responses of multi-layer/multi-dependent large geographic physical networks under Weapons of Mass Destruction (WMD) attacks such as how failures in one layer may cause cascading failures to the other layers; and develop strategies to prevent and control such cascading failures.

The main thrust of this topic is to extend prior research in networks from static to dynamical, from single layer to multi-layers, from currently existing to next generation network structures, from small/local to large/global multi-dependent physical networks, and particularly to measure/prevent/minimize/control the cascading failures that result from WMD attacks.

Some of the research areas may include (but are not limited to):

- ***Representing multi-layer/multi-dependent networks mathematically*** in large geographical scale under a WMD attack so that data analysis not only within one layer but also among different layers of entire multi-dependent networks is possible.
- ***Identifying responses of multi-layer/multi-dependent network outages*** under a single WMD attack to one layer and then multiple attacks to some of the layers of a multi-layer/multi-dependent network.
- ***Defining cascading failure survivability metric(s)*** that account for robustness, fragility, reconfigurability, and self-healing of the multi-dependent network.
- ***Modeling and analyzing dynamic information structure*** and exchange among different layers over large time régimes that cover both direct and cascading failures.
- ***Detecting, predicting and diagnosing rare WMD disruptions and cascading failures, quantifying the inter-dependency among various entities and layers,*** and developing innovative models and theories for capturing these inter-dependences.
- ***Developing algorithms and control techniques to prevent and minimize cascading failures*** such as through
    - Management algorithms for real time distribution and allocation of network resources with *minimum latency, overhead, and complexity*;
    - Adaptive control techniques and algorithms that include adaptive control methods which estimate failures and their effects at each time instance and can prioritize response via adaptive decision-making processes to stop the cascading failures.
    - Optimization techniques and algorithms developed from optimal control theory for multi-layer and multi-dependent network by minimizing certain cost functions under appropriately defined cascading-failure metrics.

High value is placed on innovative multi-layer network representations which capture essential dynamical features and interdependencies beyond static graphical representations; and control techniques for cascading failures which make networks robust to WMD stressors, speed up decision making processes and ultimately enable an automatic system responding and controlling cascading failures.

PerC-YIP-Topic 4: Understanding Multi-layer/Multi-dependent Network Responses to WMD Attacks and Developing Control Strategies for Cascading Failures (Thrust Area 2)

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

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

PerC-Topic 5: Radiation Effects in Advanced Gate Dielectrics and Channel Materials (Thrust Area 3)

Average Award Amounts for PerC-Topic 5:
- Single Scope Awards will average approximately $150,000 per year.
- Multidisciplinary Awards will average approximately $350,000 per year.

Award Structure for PerC-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: Recent significant materials and process developments, such as in atomic layer deposition, now appear to make the realization of high performance MISFET channel materials using compound semiconductors epitaxial films, germanium, or carbon based materials such as carbon nanotubes and graphene. These modified channel materials may have up to a 3-times improvement of the switching energy compared to the most advanced silicon devices. This is a result of the significantly higher intrinsic mobilities and lower effective carrier mass in these materials compared with silicon. Moreover, the continued improvement of high-K gate dielectrics, such as hafnium based layers, has allowed for order of magnitude reductions in gate leakage currents. While the development of high-K gate dielectrics is still in its infancy, it may enable the continued shrinking of silicon-based microelectronics and the extension of Moore's Law. These developments coupled with ultra-short gate lengths and semiconductor on insulator (SOI) technologies open up new vistas of advanced devices, such as gate-all-around devices, with ballistic electronic carrier transport far beyond the limitations of silicon-based technologies. These new technologies, when implemented, represent significant advancement of the current generation of microelectronics, extending the expectations of Moore's Law for at least a decade beyond the Si 5nm generations.

Currently, very little is understood with respect to radiation effects associated with these new CMOS device components (high-K gate dielectrics and advanced channel materials) including new challenges associated with length scales on the order of atomic dimensions, interfaces of complex compound materials, interfaces of non-silicon channel materials with surrounding

materials, support layers dominating the physical structure, and myriad quantum effects. Nuclear radiation and particle effects, from both terrestrial and space radiation sources, have yet to be studied in any comprehensive manner.

Impact: As advanced devices and new materials are developed that will be incorporated into the next generation of microelectronics, it is essential to maintain an early understanding of the radiation effects and tolerances of these devices so they can be more readily adopted for use by the Department of Defense (DoD). Incorporation of radiation effects mitigation procedures will be a critical technology consideration for DoD satellite assets and for any DoD system which may be subject to nuclear radiation bursts, high intensity EMP, microwave, or THz electromagnetic radiation.

Objective: The objectives of this topic are to conduct theoretical and/or experimental research to further the fundamental understanding of the radiation effects phenomena and the associated effects such as intense RF radiation mechanisms, transient effects, single event effect and total ionizing dose in advanced high-k dielectric gate stack structures, compound semiconductor interfaces, and in the interfaces of novel channel materials such as III-V compounds, graphene, germanium, etc. This research will determine the possible efficacy of these ballistic electronic carrier transport technologies for implementation in DoD systems, the development of performance restoration techniques and strategies, the development of circuit and layout design methodologies to mitigate these effects, and new utilization concepts and interactive testing to evaluate the possible use of these phenomena for DTRA mission focused activities. The approach will be based on a combination of theory, simulation, and basic research experiments.

The proposal must make the connection between the proposed basic physics research and countering chemical, biological, radiological, nuclear, or high explosive weapons or weapons effects. Submissions that focus on specific applications (not the basic enabling science), applied configuration research, or systems engineering are discouraged. Researchers are encouraged to gain an understanding of DTRA's core mission and propose novel research directions for radiation effects on advanced compound semiconductor channel materials and interfaces or high-k dielectric gates performance that further DTRA's counter-WMD mission.

PerC-YIP-Topic 5: Radiation Effects in Advanced Gate Dielectrics and Channel Materials (Thrust Area 3)

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

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

PerC-Topic 6: Kinetics and Turbulence in Chem/Bio Defeat (Thrust Area 4)

Average Award Amounts for PerC-Topic 6:

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

Award Structure for PerC-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 interested in biological-agent and chemical-agent defeat weapons to deny enemy use of WMDs and WMD facilities. It is critically important that collateral effects associated with the destruction of WMD facilities be eliminated or vastly reduced when compared to current technology. Therefore, novel energetic materials with both thermal and chemical/catalytic chem/bio-agent kill mechanisms are being investigated for weapons development. Reducing collateral effects using these novel materials require accurate simulation of the chemical species and reactions (to estimate kill percent) followed by turbulent mixing with chem/bio-agents and plume spread (to estimate longer-time environment effects).

Recent advances by researchers have developed simulation models to describe some of the mechanistic phenomena; however, there is still a lack of understanding across the field as to how agent-defeat materials perform in turbulent conditions with elevated temperature and/or pressure. Little attention has been paid to developing fluid dynamic models for clumped units of bacterial spores (micron-sized particles, similar to dust) in various turbulent flows, the differences in kill mechanisms for wet spores versus dry spores, and bio-agent heating/burning in the environmental conditions following detonation (humidity, temperature, and corrosive atmospheres). Basic knowledge of the response of chemical agents and agent simulants to blast loading and the high-temperature post-detonation environment are also inadequate.

Further, predicting where and when the fireball or detonation products are hot enough to neutralize agents, requires modeling the shock and detonation-induced instabilities leading to turbulent mixing. While mixing can be characterized on the macro scale (larger than the grid size), the micro scale (sub-grid size) still remains a challenge. Robust mixed-grid models, and in particular, uncertainty quantification in current models when various scales and grid sizes are combined, remains a challenge.

Impact: The immediate pay-off of these research efforts is: (1) a better understanding of multiphase reactive turbulent flow phenomenology and quantification of energy release; and (2) an understanding of how biological and chemical agents react to shock waves and subsequent hot corrosive environments. This understanding will improve weapon performance and optimize

tools for weapons-effects predictions.

The later impact of this research would be the capability to effectively defeat biological- and chemical-agent facilities by designing weapons to minimize collateral damage. Weapon modeling will be more accurate and validated by experimental results, enabling better damage estimates.

Objective: In order to eliminate undesired collateral effects of agent defeat weapons, the objective of this topic is to research experimentally validated equations and models for evaluating the probabilities of biological and chemical agents escaping from blast-damaged containers, getting intimately mixed with hot/corrosive detonation gases, interacting with fragments and dust, being distributed by turbulent instabilities, surviving and escaping to the environment.

Therefore, research in this topic belongs to two major categories:

- Turbulent Reactive Mixing: The objective is to gain an understanding of turbulent mixing and the instabilities of aerosolized biological and chemical agents in atmospheres of high temperature and corrosive/reactive gases. Research in computational fluid dynamics is needed to develop a novel approach to describe the mixing phenomena, especially when large higher density fragments are present along with small lower-density dust like particles. Investigation on functions that describe turbulence, and experiments on small scale mixing are needed in time scales of 10-5000 ms. Turbulence models with uncertainty quantification are desired, to assist in model efficacy and validation.
- Kinetics and mechanisms of Chemical-Agent and Biological-Agent Defeat: The objective is to gain an understanding of how spore-forming bacteria 'die' and how chemical agents are neutralized as a result of interactions with heat and reactive/corrosive gases that result from the detonation of a weapon. Research could focus on experiments to characterize heating and reactions of both wet and dry spore-forming biological agent simulants, in high temperature environments (30°C to 700°C) in contact with corrosive gases such as F_2, Cl_2, I_2, HF, HCl and HI, in an atmosphere of detonation product gases such as H_2O, NO_2, and CO. Research could also focus on neutralization or reactions of chemical agents or agent simulants at high temperatures (30°C to 700°C) and with gases such as F_2, Cl_2, I_2, HF, HCl and HI, in an atmosphere of detonation product gases such as H_2O, NO_2, and CO; and the reaction products resulting from these conditions.

PerC-YIP-Topic 6: Kinetics and Turbulence in Chem/Bio Defeat (Thrust Area 4)

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

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

PerC-Topic 7: Polymers and Binders for Chem/Bio Defeat Formulations (Thrust Area 4)

Average Award Amounts for PerC-Topic 7:

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

Award Structure for PerC-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: DTRA is interested in biological- and chemical-agent defeat weapons to deny enemy use of WMD facilities. We are currently supporting many research projects looking for chemical and biological agent defeating explosive and reactive materials. Some of these projects are resulting in very effective bio- and chem-agent defeat explosives or reactive materials. Usually, the next step in weapon development is that such new explosive- or reactive- materials ingredients are formulated with binders and additives (though less than 20% of the mix), to be utilized in different weapon configurations or in different methods of weapon deployment.

Properties such as the malleability of an explosive, the ability to be poured and set, to be sprayed or pumped, adhered to a surface and then set, etc. are usually established by the polymers or binders or adhesives, which are incorporated with the reactive or energetic material, together with additives that allow setting or gluing, etc. Key characteristics of such binder systems would include viscosity, compressibility, and adhesion to a wide range of surfaces; in addition to compatibility with the explosive or reactive ingredients. One possible curing mechanism for binders for spray-slurry adhesive explosives may be an anaerobically stable polymeric binder that retains a low enough viscosity for spraying and then adheres and thickens (cures) in air, perhaps with prolonged evaporation of solvent.

Further, the most-effective chemical and biological defeating explosive and reactive materials being investigated are reactive with liquid water and water vapor (humidity), are reactive with oxygen (in air), and sometimes react with other ingredients in the formulation. These reactions or interactions with the environment cause breakdown of the biological/chemical-agent defeat properties of the explosive or reactive material during handling and storage. For example, metal fuel particles spontaneously oxidize when exposed to air; new halogen-oxidizers are so hydroscopic that they turn in to puddles with even a few minutes in high humidity. Such highly reactive yet most-effective explosive or reactive materials could only be utilized with the protection or passivation offered by a coating or binder system that would stabilize them in normal environments. For incorporation of these new chemical and biological defeating explosives and reactive materials into plastic-bonded explosives (PBXs), the characteristics of

the polymer, such as its mechanical properties, wetting of fill particles, crosslink density, glass transition temperature, ability to accept bonding agents, and cure at ambient temperature are important properties to consider. Some current binder systems in explosive formulations in wide use today are estane/BDNPA (PBX-9501), Kel-F (PBX-9502), and HTPB (PBXN-109).

Recent advances in block co-polymers, especially asymmetric co-polymers, polymers with hydrophilic or hydrophobic ends, polymers binding to nano-particles, etc. abound in scientific literature. Such new polymeric, organic and inorganic materials are reported to yield thermo-setting, air-setting, or water-setting abilities, and properties that form permeable or impermeable barriers as desired.

Impact: The pay-off of these research efforts is chemical and biological agent defeating explosive and reactive material formulations, which are formable, spray-able or pourable, with highly effective ingredients that are protected from possible water, air or other undesired interactions during handling and storage. The final impact of this research would be customized weapons to completely and effectively defeat and destroy biological- and chemical-agent facilities and prevent WMD use by adversaries, while minimizing collateral damage.

Objectives: Investigate polymers, binders or adhesives, and the appropriate additives, for agent-defeat energetic formulations; with ingredients (already being researched) that are made water-proof or air-proof, or other otherwise isolated from undesired interactions; and can be hand-formed to different shapes, poured, or sprayed, and adhere to different surfaces, as desired for particular deployment of counter-WMD weapons. The characteristics of the polymer, such as its mechanical properties, wetting of fill particles, crosslink density, glass transition temperature, ability to accept bonding agents, and cure at ambient temperature are important properties to address in the white paper. For basic research, initial work proposed may use sugar crystals as mock or simulant of energetic-material crystals.

One approach could be an anaerobically stable polymeric binder system that is impermeable to air, and retains a low enough viscosity for spraying and then adheres and thickens (cures) in air, perhaps with prolonged evaporation.

Another approach could be an amphiphilic coating that would protect air- and water-reactive energetics and then bonds with existing binders (such as those based on polybutadiene or fluoropolymers).

White papers with these or other novel and creative approaches are sought that yield the above objectives.

PerC-YIP-Topic 7: Polymers and Binders for Chem/Bio Defeat Formulations (Thrust Area 4)

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

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

PerC-Topic 8: Novel Physicochemical Signatures of Radiation Exposure History for Treaty Compliance (Thrust Area 5)

Average Award Amounts for PerC-Topic 8:

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

Award Structure for PerC-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: The physical inspection of elements dismantled from a state nuclear arsenal may be needed in future arms control treaty compliance and verification. Current treaties, such as New START, focus on strategic nuclear armaments and are enacted by limiting large scale elements of a nuclear arsenal such as individual warheads, bombers, missiles, and launchers. As future arms control treaties are developed the need to track and verify the history of individual components within a weapon system, such as a section of metal alloy, could arise. The development of basic research that can accurately describe the time-dependent radiation exposure history of these components could be extremely valuable in supporting such future treaties.

In order to verify treaty compliance but protect state secrets, rapid and reliable conclusions about the provenance of an item presented to an inspectorate must be produced. These methods must be scientifically sophisticated enough to conclusively identify the composition and time-dependent radiation exposure history of a component from a dismantled nuclear weapon system. As a complement to conventional nuclear detection techniques, unique physicochemical signatures may be a valuable way for the onsite inspection (OSI) team to determine if the object presented matches its declared use and history. Some challenges in this area of analysis include efficient identification of the material, verification of the materials history including time exposure data, and analysis in a small time interval with low measurement uncertainties. The development of techniques for this purpose will advance the capabilities of future OSI teams and their ability to assure state compliance with treaties in-force.

Impact: Research into the physicochemical signatures of time-dependent radiation exposure addresses DTRA's counter-WMD need by providing the scientific basis needed to develop equipment, analysis methods, and concept of operations to conduct a successful OSI for future treaties.

Objectives: The topic explores research into determining the unique physicochemical signatures needed to enable the proper identification of materials from a weapon system, including but not

limited to metals, alloys, paints, lubricants, and polymers. Signatures are desired that can be physically understood, modeled or simulated, and accurately predicted. Research areas should not focus on the development of new radiation sensitive detector materials but rather, on the radiation exposure history of existing materials. Specific interests include nondestructive determination of a material's exposure to radiation from a weapon, the time-dependent history of the exposure, and predictive models that support conclusive identification. Proposals investigating basic scientific phenomena of these non-nuclear signatures are preferred to proposals suggesting devices to accomplish the research. Proposals that engage government laboratory institutions are also encouraged.

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

- Determination of unique physicochemical signatures through advanced analysis techniques such as:
  - Mass spectrometry such as SIMS or GC-MS to look for changes in the elemental or molecular composition of the material
  - Microscopy techniques such as AFM or SEM to identify microstructural or morphological changes
  - Optical or surface spectroscopy such as Raman spectroscopy or ellipsometry to identify subtle chemical or physical property changes
  - Bulk measurement techniques such as nanoindentation or conductivity tests to quantify changes in hardness or charge mobility
  - Imaging techniques such as hydroacoustic imaging or x-ray to probe subsurface structural shifts or defects
- Novel methods to investigate both time-integrated and time-dependent radiation exposure history of a component
- Methods to distinguish between physicochemical signatures of operational radiation exposure and artificial aging of a component from a variety of radiation sources, both stockpile-relevant and other

---

PerC-YIP-Topic 8: Novel Physicochemical Signatures of Radiation Exposure History for Treaty Compliance (Thrust Area 5)

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

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

PerC-Topic 9: Interaction of Substrate-Mediated Transport and Catalyst Kinetics in Multicatalyst Systems (Thrust Area 3)

Average Award Amounts for PerC-Topic 9:

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

Award Structure for PerC-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: Certain biological catalysts exhibit kinetics faster than the rate of substrate diffusion. This behavior has been variously attributed to, for example, (a) the ability of the catalyst scaffold to draw in and pre-orient substrate via dipolar electric fields or (b) for certain substrates (protons, electrons), quantum mechanical tunneling through the activation barrier to reaction.[5] It has also been suggested that the recently observed phenomenon of enzyme chemotaxis may play an underappreciated role in the activity of certain systems.[6] The ability of enzymes and scaffold components to respond to their environment by selectively directing mass transport is thought to play a fundamental role in the efficiency of biological catalytic cascades such as polymerases and many dehydrogenases.[7]

Scientists and engineers seeking to heterogenize homogeneous catalysts, for a wide variety of defense and industrial applications including those relevant to C-WMD, typically find a tradeoff between the desirable attributes of, on the one hand, the ability of the heterogeneous system to be compartmentalized and separated from the reaction mixture and, on the other hand, the more rapid rates of homogeneous catalysts. Mass transport limitations are thought to play a major role in diminishing the reactivity of heterogeneous catalysts, and today this is only partially mitigated by the use of highly porous scaffolds. [8] Strategies to introduce spatially anisotropic chemistry and topology into synthetic catalyst scaffolds have not been widely applied. However, the

---

[5] Doshi, U.; McGowan, L. C.; Ladani, S. T.; Hamelberg, D. Resolving the complex role of enzyme conformational dynamics in catalytic function. Proceedings of the National Academy of Sciences of the United States of America 109, 2012, 5699-5704.

[6] Muddana, H. S.; Sengupta, S.; Mallouk, T. E.; Sen, A.; Butler, P. J. Substrate Catalysis Enhances Single-Enzyme Diffusion. Journal of the American Chemical Society, 132, 2010, 2110-2111.

[7] Perham, R. N. Swinging Arms and Swinging Domains in Multifunctional Enzymes: Catalytic Machines for Multistep Reactions. Annual Review of Biochemistry 69, 2000, 961-1004.

[8] Li, B.; Guan, Z.; Wang, W.; Yang, X.; Hu, J.; Tan, B.; Li, T. Highly Dispersed Pd Catalyst Locked in Knitting Aryl Network Polymers for Suzuki-Miyaura Coupling Reactions of Aryl Chlorides in Aqueous Media. Advanced Materials 24, 2012, 3390-3395.

technology for tuning materials in this manner is increasingly refined,[9,10,11] and we believe that its convergence with the biological community will prove to be a fruitful pathway to both (a) better understand the role of substrate-mediated transport in biological multicatalyst systems and (b) develop the fundamental understanding needed to design disruptive materials for sensing, diagnostics, medical intervention, and protection. The fabrication of model synthetic systems and re-engineered natural ones as tools in elucidating the role of substrate-mediated mass transport provides a focus to this convergence.

Impact: By means of accomplishing the objective articulated below, this research topic seeks to establish structure/property relationships that enable (a) design and tailoring of materials incorporating functionalities necessary for meeting DTRA C-WMD challenges; (b) understanding the response of natural and synthetic multicatalyst systems to relevant environmental variables; and (c) development of targeted effectors that alter the function of multicatalyst systems. Therefore, the knowledge generated as a result of conducting the research will be broadly applicable to core DTRA mission requirements for sensing and recognition, personnel protection, medical countermeasures, and treaty monitoring/verification. In addition, the research will support larger DoD goals for engineering of novel multifunctional materials to address a variety of critical mission needs.[12,13]

Objective: Elucidate the role of substrate-mediated mass transport in the kinetics of multicatalyst systems by developing the predictive understanding required to couple new paradigms of directed molecular transport with the activity of supported catalysts.

The most competitive responses will, as tools to accomplishing this objective, develop and interrogate relevant multicatalyst model systems (here defined as heterogenous systems composed of two or more catalysts) or re-engineered natural systems that can: (1) rapidly separate components in a heterogeneous mixture, (2) selectively funnel individual components to and from specific catalytic centers, and (3) employ low-energy transport processes, ideally those relying only on ambient thermal energy and physicochemical interaction of the substrate with the scaffold and catalysts. Biotic, abiotic, or hybrid catalytic systems will be considered relevant to the goals of this research topic.

Competitive responses will likewise present a strategy that combines a theoretical approach, driven by a series of testable hypotheses, with material fabrication and evaluation; in particular, application of combinatorial design and computational learning algorithms is encouraged, as is modeling of substrate/scaffold/catalyst interactions, as framed within a careful design of experiments.

---

[9] Genzer, J.; Bhat, R. R. Surface-Bound Soft Matter Gradients. Langmuir 24, 2008, 2294-2317.
[10] Yonet-Tanyeri, N.; Evans, R. C.; Tu, H.; Braun, P. V. Molecular Transport Directed via Patterned Functionalized Surfaces. Advanced Materials 23, 2011, 1739-1743.
[11] Perl, A.; Gomez-Casado, A.; Thompson, D.; Dam, H. H.; Jonkheijm, P.; Reinhoudt, D. N.; Huskens, J. Gradient-driven motion of multivalent ligand molecules along a surface functionalized with multiple receptors. Nature Chemistry 3, 2011, 317-322.
[12] Committee on Materials Research for Defense After Next National Materials Advisory Board. Materials Research to Meet 21st-Century Defense Needs. The National Academies Press, Washington, D.C., U.S.A., 2003.
[13] Department of Defense Research and Engineering. Strategic Basic Research Plan, 2008, 13-15.

While the intent is to develop basic understanding, specific explored model systems must be shown to be relevant to countering the threat posed by weapons of mass destruction. For example, long-term relevance to one of the following could be established:

- Multicatalyst systems able to actively and selectively catalyze the binding and signal amplification of radioactive residues or non-radioactive environmental indicators of WMD materials production, reprocessing, manufacturing, and storage

---

PerC-YIP-Topic 9: Interaction of Substrate-Mediated Transport and Catalyst Kinetics in Multicatalyst Systems (Thrust Area 3)

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

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