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Research and Development Directorate (RD)

Enabling Capabilities Department (EC)

Interaction of Ionizing Radiation with Matter University Research Alliance (IIRM-URA)

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OVERVIEW INFORMATION

Agency Name:

Defense Threat Reduction Agency (DTRA)
Research and Development (RD) Directorate
Enabling Capabilities Department (EC)
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Fort Belvoir, VA 22060-6201

Funding Opportunity Title: Interaction of Ionizing Radiation with Matter University Research Alliance (IIRM-URA) Broad Agency Announcement (BAA)

Announcement Type: This is an initial announcement of this funding opportunity.

Funding Opportunity Number: HDTRA1-19-S-0004

Catalog of Federal Domestic Assistance (CFDA) Number: 12.351

Dates: Applicants must submit a Letter of Intent (LoI) no later than 21 June 2019 to be considered eligible to submit a Phase I pre-proposal. Phase I pre-proposal submissions are due on 17 July 2019.

ADDITIONAL OVERVIEW INFORMATION

Purpose: Recent advancements in materials science make studies on how ionizing radiation interacts with new materials an ideal area for DTRA basic research investment. Improved understanding will advance the state of the art for radiation detectors, survivability of Department of Defense (DoD) systems, and military functionality following a nuclear event. Some of the overall goals of the science would be to enable: radiation sensing from multiple platforms; cost effective hardening and hardness testing of DoD systems; and safe and efficient military operations in a nuclear environment.

According to the 2018 Nuclear Posture Review, “the United States will sustain its specialized capabilities to search for, interdict, characterize, and disable nuclear devices.” In order to fulfill this mission capability, research into novel radiation sensor materials can provide improved efficiency and energy resolution while also offering superior robustness over current materials and methods. Understanding the phenomenologies governing novel materials may lead to new strategies for radiation-sensing materials and alternative sensing methodologies.

The DoD must be prepared to survive and respond to a nuclear event on foreign soil, domestic soil, or in space. A nuclear explosion poses a variety of threats from the thermal blast, overpressure, electromagnetic pulse (EMP), prompt ionizing radiation, and nuclear fallout. The DoD’s equipment, systems, and personnel must be able to survive and operate in a nuclear environment.

Two of the main pillars of the 2018 Nuclear Posture Review are to: 1) “achieve U.S. objectives should deterrence fail;” and 2) “hedge against an uncertain future.” DTRA's basic research program addresses these two pillars, in part, by improving the DoD's capability to survive and respond to a nuclear attack. To succeed in this goal, DTRA invests in research for innovative materials or methods that can shield or defend against the effects of nuclear weapons, ensuring that the warfighter can operate in a nuclear environment. Additionally, the DoD will also be charged with collecting and analyzing debris samples from a nuclear event. Furthermore, DTRA

is tasked with maintaining and operating the United States (U.S.)-owned stations of the International Monitoring System, which monitors the planet for any sign of a nuclear explosion.

A joint theme through all of these missions is the interaction of ionizing radiation with matter. While the material, radiation type, or desired interaction may differ, there is significant overlap in the relevant physics, modeling approaches, and device design. The Interaction of Ionizing Radiation with Matter (IIRM) University Research Alliance (URA), collectively known as the IIRM-URA, seeks to exploit these overlaps in physics and approaches for collaborative and synergistic advances in understanding material radiation interaction, advancing devices and integration, and advancing nuclear survivability and response.

The Research Areas (RAs) for the IIRM-URA are as follows:

- Materials
- Devices and Integration
- Survivability and Response

In addition to these three RAs, Modeling and Simulation has been identified as a Cross Cutting Research Initiative (CCRI) that is inherent in each of the RAs and that must be jointly studied with the RAs to make fundamental advances in IIRM.

DTRA anticipates that the predominance of work conducted by the IIRM-URA will be fundamental research as defined in National Security Decision Directive (NSDD) 189, National Policy on the Transfer of Scientific, Technical, and Engineering Information. Initially the research conducted by the IIRM-URA will align under Budget Category 6.1 (Basic Research) funding. However, to provide the Government with the most flexibility, the cooperative agreement (CA) will also allow participation from other Government agencies and may result in additional Budget Category 6.1 funding as well as some Budget Category 6.2 funding (Applied Research funding; see discussion of Enhanced Program in Section 1.6). Thus, the research conducted for the IIRM-URA will fall within the first four Technology Readiness Levels (TRLs).

Award Instrument and Structure: This Broad Agency Announcement (BAA) is expected to result in the award of a cooperative agreement (CA) as defined at 31 United States Code (U.S.C.) 6305 for the execution of the program. The CA will be awarded to a U.S. institution of higher education to lead an Alliance organization that may include U.S. and foreign institutions of higher education, DoD-Degree Granting Colleges and Universities, DoD Service Laboratories, Federally-funded research and development centers (FFRDCs) to include Department of Energy (DOE) National Laboratories, U.S. industrial partners, and/or U.S. and foreign non-profit organizations to include University Affiliated Research Centers (UARCs). Applicants should take great care to substantiate involvement of foreign-based organizations. At this time, performance under the CA is not limited to individuals designated as U.S. Persons; however, individual participation could be limited in the future based on DoD policy changes.

The Alliance must be led by a U.S. institution of higher education charged with spearheading the focused basic research program; this organization will be designated as the Lead Research Organization (LRO). Each Research Area (RA) will be led by a different U.S.-based institution of higher education; these organizations will be designated as the Lead Research Area Organizations (LRAOs). The LRO may act as the LRAO for one RA; however, the same entity

cannot be the LRAO for more than one RA. It is expected that each LRAO will make significant scientific contributions to the respective RA and to the Alliance, as a whole. As such, DTRA anticipates that the LRO and the LRAOs will provide multiple PIs to work across the Alliance to create a matrix of PIs to address the research within the RAs. Collectively, the LRO and the LRAOs should demonstrate capabilities for scientific leadership and research.

Together the LRO and LRAOs make up the permanent Alliance members, who are responsible for shaping and steering the URA through collaboration with DTRA. Collectively the URA members and DTRA make up the Consortium. Performance under the URA and resulting CA will also include organizations beyond the LRAOs. These entities will be subawardees to the LRO and considered non-permanent members of the URA.

Alliances are encouraged to include Historically Black Colleges and Universities and Minority Institutions defined in 10 U.S.C. § 2362(e).

While DTRA anticipates that a single award may be made from this BAA, the Government reserves the right to fund all, some, or none of the proposals submitted; may elect to fund only part of any or all proposals; and may incrementally fund any or all awards under this BAA. The Government also reserves the right to request applicants make any changes necessary to documents submitted as part of an application package to increase the feasibility of making the proposal fundable. Applicants may decline to participate in any revisions to application packages requested by DTRA.

Proposal Submission: The BAA will be conducted in two phases; however, applicants must submit a non-binding LoI to be considered eligible to submit a Phase I package. Phase I is for receipt and evaluation of pre-proposal submissions. Phase II is for receipt and evaluation of invited proposal packages. Invitation to submit a Phase II proposal will be based on the evaluation results of the Phase I pre-proposal submission.

The LoI is required; however, it is not legally binding and does not enter into the review of Phase I or Phase II packages. The information in the LoI will allow DTRA to estimate the potential review workload and plan for the review. By 21 June 2019, prospective LROs must submit a LoI to the email address in Section 7. The LoI should minimally include the following information:

- Identification of the LRO and the LRAOs
- Name, address, and email address of the IIRM-URA Program Manager (PM)
- Names and associated affiliations of other known key personnel
- A list of participating institutions known at the time of the letter preparation
- Number and title of this BAA

All submissions must be made in accordance with the submission instructions in this BAA through www.grants.gov using the application packages linked with this BAA (under the "Package" tab) on www.grants.gov. Applicants are responsible for ensuring compliant and final submission of all applications. Any submission that does not conform to the requirements outlined in the BAA and in the invitation for Phase II submissions will not be reviewed or considered further.

Period of Performance: Efforts may be proposed for five years with two additional two year

options. The total possible period of performance is nine years.

Funding: Estimated funding for the CA is anticipated to be from $5M to $6M annually (total, including both direct and indirect costs) depending on the nature and the scope of work. This BAA is issued subject to the availability of funds. The funding levels provided are to allow applicants to prepare estimates only. Payments on CAs will be made in advance, subject to the conditions described in 2 Code Federal Regulations (CFR) 200.305.

Profit/Fee: In accordance with 32 CFR §22.205, profit/fee is not permitted under the CA.

Cost Sharing: Cost sharing is not required under this BAA; however, efforts that include cost sharing or in kind contributions are allowed.

Terms and Conditions of Awards: Any CA awarded under this announcement will be governed by the award terms and conditions, which conform to DoD's implementation of The Office of Management and Budget (OMB) circulars applicable to financial assistance. This includes DoD implementation of OMB guidance in 2 CFR Part 200, "Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards."

1. PROGRAM DESCRIPTION

1.1. Introduction

The Defense Threat Reduction Agency (DTRA) safeguards America and its allies from weapons of mass destruction (WMD) and provides capabilities to reduce, eliminate, and counter the threat and effects from chemical, biological, radiological, nuclear, and high yield explosives. DTRA seeks to identify, adopt, and adapt emerging, existing and revolutionary sciences that may demonstrate high payoff potential to Counter-WMD (C-WMD) threats. As a combat support agency, DTRA provides both operational support and specialized capabilities in science and technology (S&T). The Agency is the premier Department of Defense (DoD) source of science-based WMD expertise and a sponsor of basic research focused exclusively on WMD threat reduction.

Overcoming the most difficult technical challenges for combatting WMD requires revolutionary advancements in S&T. Only strategic investment in basic research will lead to the scientific breakthroughs needed for future WMD threat reduction. The strategy for the basic research program is to target unique C-WMD challenges within DTRA's mission space. The program's goals are as follows:

- Train the next-generation workforce;
- Advance the fundamental knowledge and understanding in the sciences;
- Promote university research to support WMD threat reduction; and
- Facilitate transition of research that enables new capabilities for the warfighter.

The program avoids preconceptions about specific applications or solutions in order to preserve the integrity of basic research. However, to maintain the relevance of the program to the larger DTRA mission and to ensure focus on the strategic goal of transitioning the research to enable new capabilities for the warfighter, the applied research requirements across the Agency are used to inform our choices. This approach has successfully attracted outstanding research institutions and a new generation of scientists into the field of WMD threat reduction. It also provides a hedge against the uncertainty of future threats and technology surprise.

To continue and expand on the program's success to date, DTRA is evolving the investment strategy for basic research. DTRA intends to establish a new partnership that seeks to investigate the Interaction of Ionizing Radiation with Matter (IIRM) in the context of future WMD-relevant operations through a new University Research Alliance (URA) that will consist of United States (U.S.) university researchers working to solve complex problems. The Interaction of Ionizing Radiation with Matter University Research Alliance (IIRM-URA) seeks to advance the understanding of material-radiation interaction, advancing radiation detection and radiation hard devices and integration, and advancing nuclear survivability and response.

DTRA strongly believes that a joint collaborative approach by a multidisciplinary team of researchers is required to make fundamental advances towards meeting the URA goal of developing a fundamental understanding of the interaction of ionizing radiation with various materials and devices that are relevant to the DoD. DTRA has identified three interrelated Research Areas (RAs) that, when jointly studied, will advance the fundamental foundations of IIRM in the context of future operations. These RAs and the suggested relative funding levels noted in percentages of the research dollars are:

- RA1—Materials (~35%),
- RA2—Devices and Integration (~20%), and
- RA3—Survivability and Response (~20%).

In addition to these three RAs, Modeling and Simulation (5-10%) has been identified as a Cross-Cutting Research Initiative (CCRI) that is inherent in each of the RAs and that must be jointly studied with the RAs to make fundamental advances in IIRM. Finally, DTRA anticipates that the remaining 10-15% of the research dollars will be utilized for Student Pipeline Development.

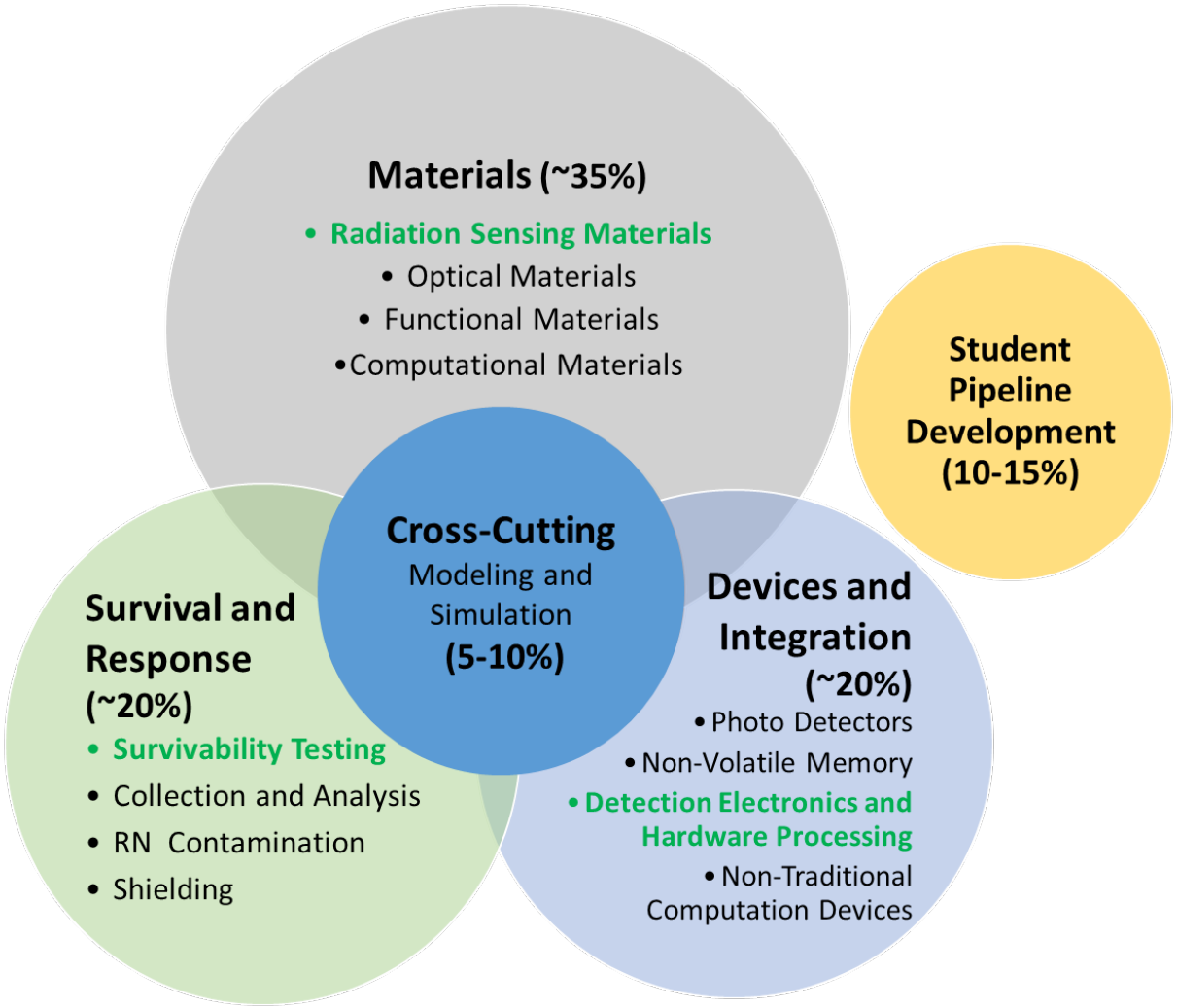


Figure 1: General structure of the IIRM-URA.

The IIRM-URA is intended to create a collaborative, matrixed environment that enables the Alliance to advance the state-of-the-art and to take advantage of the diverse scientific capabilities and viewpoints of both the academic sector and government personnel. The IIRM-URA will work collaboratively with DTRA Technical Points of Contact (TPOCs) to develop research programs and identify areas where joint, multidisciplinary, collaborative research is advantageous. Continuous collaboration through technical exchanges, site visits, student development, outreach opportunities, etc., will strengthen and improve the IIRM-URA research

and its relevance to the DoD. As part of the URA, DTRA personnel will have substantial involvement throughout the lifetime of the Alliance, which may include engaging in deep and meaningful collaborative research across the URA team.

Each RA is composed of four Focus Areas (FAs). The FAs include the basic research needs DTRA has identified that may enable technology development within each RA. FAs may evolve over the lifetime of the URA. The FAs highlighted by green text in Figure 1 must be addressed within the Draft Initial Program Plan (IPP) of the proposal. The remaining FAs shown in black in Figure 1 may be addressed in the Draft IPP or in the follow-on Biennial Program Plans (BPPs). Applicants should take care to demonstrate an understanding of all RAs and FAs to include a logical progression of research over time in the preproposal and full proposal technical narratives. Further, applicants should demonstrate appropriate expertise to address the breadth of the FAs and RAs. DTRA is keenly interested in approaches that include a matrix of personnel from the LRO, LRAOs, and non-permanent subawardees across the RAs and FAs

1.2. Programmatic Strategy

The CA will be awarded to a U.S. institution of higher education to lead an Alliance organizations that may include U.S. and foreign institutions of higher education, DoD-Degree Granting Colleges and Universities, DoD Service Laboratories, FFRDCs to include DOE National Laboratories, U.S. industrial partners, and/or U.S. and foreign non-profit organizations to include University Affiliated Research Centers (UARCs). Applicants should take great care to substantiate involvement of foreign-based organizations. Unfunded collaboration with foreign non-profit organizations and foreign governmental research organizations, such as the Atomic Weapons Establishment (AWE) and the Defense Science and Technology Laboratory (DSTL), will be considered.

The Alliance will work in collaboration with DTRA TPOCs to advance the state-of-the-art in IIRM to meet the challenges of future military operations. DTRA and the URA selected for award will establish the Consortium that will work collaboratively to conduct basic research addressing key scientific gaps and barriers critical to IIRM. Additionally, other government agencies may participate in the Consortium and contribute their technical expertise, personnel, and facilities. A significant goal of this effort will be to create a critical mass of collaborating, matrixed scientists and engineers focused on solving ionizing radiation research challenges outlined within the scope of the IIRM-URA. This intellectual synergy is also expected to include sharing equipment, personnel, and facilities to promote efficiency and enhance collaboration.

It is anticipated that the predominance of work conducted by the IIRM-URA will be fundamental research as defined in National Security Decision Directive (NSDD) 189, National Policy on the Transfer of Scientific, Technical, and Engineering Information. Fundamental research is basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons. Contracted fundamental research includes research performed that is (a) funded by Budget Category 6.1 (Basic Research), whether performed by universities or industry or (b) funded by Budget Category 6.2

(Applied Research) performed on-campus at a university[1]. Fundamental research provides for science and technology (S&T) research and early applied development. It seeks to lower performance risk to a manageable level and facilitate transition and funding to capability end-state programs.

Initially the research conducted by the IIRM-URA will align under Budget Category 6.1 (Basic Research) funding. However, to provide the Government with the most flexibility, the CA will also allow participation from other Government agencies and may result in additional Budget Category 6.1 funding as well as some Budget Category 6.2 funding (see discussion of Enhanced Program below). Thus, the research conducted under the IIRM-URA CA will fall within the first four Technology Readiness Levels (TRLs). TRLs provide a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology.

The research strategy developed by the applicant should adopt a systematic approach to fundamental research focused on understanding ionizing radiation-related phenomena in matter so that techniques can be used (1) to learn to better bridge energy deposition into novel device behavior; (2) to devise testing and measures that increase options for protection and survivability against radiation and radioactive products; and, (3) to uncover hidden insights and meaningful events and anomalies. This research should lead to an elucidation of fundamental laws, theories and theoretically grounded and empirically validated models that enable design of dynamic, adaptive, and goal-driven ionizing radiation source detection and countermeasures to their use as WMD. Applicants must carefully choose research topics to create a substantial group of researchers from diverse technical fields addressing the challenges proposed. Applicants are suggested to apply the following suggested allocation of resources for the three RAs over the lifetime of the Alliance:

- RA1—Materials (~35% of the research dollars),
- RA2—Devices and Integration (~20% of the research dollars), and
- RA3—Survivability and Response (~20% of the research dollars)

Research in each RA must be interdisciplinary in order to inform and be informed by the developments in the other two RAs given the strong inter-dependencies between the three RAs. Research topics may have multiple institutions researching a given topic. Additionally, each institution may participate in research in multiple topics and areas. In addition to these three RAs, Modeling and Simulation (5-10%) has been identified as a CCRI that is inherent in each of the RAs and that must be jointly studied with the RAs to make fundamental advances in IIRM. Thus, the research dedicated to each area must address the CCRI. The CCRI resources are an integral part of the RA efforts. Finally, DTRA anticipates that the remaining 10-15% of the research dollars will be utilized for Student Pipeline Development. These research activities should account for 100% of the research dollars including the research activities at the LRO. No more than 50% of the total direct dollars may remain at the LRO for the conduct of administrative and research activities.

This BAA is to solicit the most creative, innovative, and flexible approaches to the ultimate goal

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

of generating and exploiting research to solve pressing research gaps and issues impacting both the military and commercial sectors. This BAA seeks Phase I pre-proposal submissions and invited Phase II proposal submissions; this BAA may result in the award of a single CA. In response to the BAA, applicants will be required to:

- Define the strategy for implementing an approach which synergistically integrates the three RAs and the CCRI and outline the metrics by which success of the program is expected to be measured.
- Scope and define the research, appropriate to the overall funding of the URA, ensuring all elements of the proposed research are tightly integrated in a way that the results of the research in one area support and enhance the results in other areas. Applicants should identify the most critical research issues and describe how the set of research efforts meet the goals of this program. Sufficient resources should be allocated to ensure enough critical mass to make fundamental progress.
- Formulate a basic research program which clearly demonstrates innovative, detailed and substantive scientific plans to address each of the three RAs and the CCRI. The proposal should clearly articulate the applicant's vision for the area and the applicant's research goals for the program (the base period and for each additional option).
- Present the experience, qualifications and availability of the scientific staff and the quality and relevance of research facilities.
- Identify approaches to building collaborations within the Alliance and with DTRA, which are essential to the success of the IIRM-URA.
- Identify the overall management (business plan) and programmatic and administrative team with the expertise to achieve the stated research goals and to oversee and manage finances, reporting, data, meetings, reviews and intellectual property.

1.3. Research Strategy

The three Research Areas (RA) for the IIRM-URA, their respective FA, and the CCRI are described below.

1.3.1. RA1: Materials. RA1 is focused on the fundamental interactions of ionizing radiation (photons, electrons, protons, neutrons, and heavy ions) with materials. Of particular interest are radiation interactions with new materials, functional materials, and materials being used in new ionizing radiation relevant applications. Experimental, modeling, and computational lines of effort are expected to be relevant to this research area. RA1 is composed of four (4) FAs: FA1 – Radiation Sensing Materials; FA2 – Optical Materials; FA3 – Functional Physical Materials; and FA4 – Functional Computational and Electronic Materials.

RA1-FA1: Radiation Sensing Materials (Must be addressed in the draft IPP)

This FA seeks research into novel radiation sensor materials that provide improved efficiency and energy resolution but also offer superior robustness over current materials. Current sensor materials are either bulky or brittle (NaI, High Purity Ge), are limited in size due to growth constraints (cadmium zinc telluride), or possess poor energy resolution and efficiency for gamma-rays (plastic scintillators). We envision a new class of materials that possess excellent response (resolution and efficiency) and are also mechanically robust, lightweight, and have the

versatility to be produced in a variety of unconventional sizes and shapes.

Current radiation detection technologies suffer from setbacks generated by making tradeoffs for many desired features. Tradeoffs include the following:

- High detector efficiency which demands large area detectors with large power supply needs.
- Good pulse shape discrimination from high radiation backgrounds which may incur longer detection times.
- Lightweight and low-cost detector designs which generally yield high uncertainties from their poorly-resolved results.

Understanding the phenomenologies governing novel materials may expose new insights available for radiation-sensing materials and alternative sensing methodologies.

Potential research could investigate material interaction with gamma and neutron radiation, new or innovative material growth methods, or physical and mechanical material properties. Fundamental studies of the interaction of matter and mechanisms of transfer of energy are critical for successful development of nuclear sensing methodologies. The investigation of scintillation and other fundamental radiation interaction phenomena to improve resolution and other direct radiation sensing parameters is also of interest. Additional areas of interest include: studying synthesis/fabrication-ease and basic properties that enable flexible employment; scintillators for fabrication in any shape desired to become weight-bearing structures; additive manufacturing for printable scintillators and improved mechanical robustness of scintillators; materials development of high-efficiency solid-organic or plastic scintillators; and growth methods to develop unconventional detector shapes and designs; similarly, address these issues for novel sensing materials other than scintillators.

Research could also investigate:

- The combination of neutron and gamma imagers into one system through materials research.
- Cosmic radiation for ultra-trace but discernible measurements
- Flexible-nanostructured radiation sensors providing real-time dose reconstruction (nanomaterial dosimeter alternative)
- New physical sensing mechanisms for finding and characterizing radiation emitters
- The interaction of ionizing radiation with common building materials, to include the study of ubiquitous materials' response to possible proliferation signatures and exploring if time stamp information could be derived from the radiation interaction history.

Bridging the scientific and technical synergistic knowledge of nanoscience, quantum science, and sensor sciences is also of interest. Areas for investigation could include nano-based tagging, nanorobotics and nanosensors. This includes nanostructured materials that could be incorporated into room-temperature radiation sensors with excellent energy resolution. This area of research could include:

- 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.
- Residual changes in a material at the nano- or micro-scale that identify exposure to ionizing radiation.
- 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 the detection, characterization, and counting of radiation.

References for RA1-FA1:

Mishnayot, Y., Layani, M., Cooperstein, I., Magdassi, S., & Ron, G. (2014). Three-dimensional printing of scintillating materials. Review of Scientific Instruments, 85(8), 085102.

D. McCarthy, S. O'Keeffe, G. Leen and E. Lewis, "Optical fiber radiation dosimetry for low dose applications," SENSORS, 2010 IEEE, Kona, HI, 2010, pp. 1663-1666. doi: 10.1109/ICSENS.2010.5689945

RA1-FA2: Optical Materials

Optical systems and devices have performance and reliability advantages over conventional electrical systems and devices. However, there are a number of unanswered questions with respect to the interactions of ionizing radiation with optical materials. This research area focuses broadly on three DoD-relevant optical material applications: high speed optical communication, propagation and collection of scintillated light, and optical coatings and cover glasses.

Ionizing radiation has been observed to increase optical absorption (loss), shift refractive index, and create color centers in waveguides. Displacement damage in silica-based optical fibers is not of interest. Investigations of displacement or total dose damage in other optical materials should be connected to larger optocoupler or optical interconnect systems.

One research area of interest is single event effects (SEE) and dose rate effects on optical interconnects. Recent modeling studies have suggested that a heavy ion strike could deposit sufficient charge in a waveguide to temporarily modify the refractive index and disrupt high speed optical communication. Significant work remains to quantify and experimentally demonstrate this effect. The long lengths of optical interconnects may also make them susceptible to high dose rate effects.

Another area of interest is the transport and collection of scintillation light for optimization of non-conventionally shaped scintillation based detectors. Flexible, conformal, or structural scintillation materials present unique challenges for transportation and efficient collection of light.

References for RA1-FA2:

Goley, Patrick S.; Fleetwood, Zachary E.; Cressler, John D.; IEEE TRANSACTIONS ON NUCLEAR SCIENCE; Volume: 65 Issue: 1 Pages: 141-148 Part: 1 Published: JAN 2018

RA1-FA3: Functional Physical Materials

Major functions for detector materials include direct interactions with radiation, subsequent internal transport of charge and photons, and integrated computationally functional materials to record and process the creation of interaction products. Another category of interest is the use of physically functional materials to support these areas and improve detectors. Such support may provide energy, smart materials response, or enhanced ability for deployment of detectors under different platforms. Another possible function that a material may serve is to transduce the output energy into a form more readily useful for supporting data storage and information processing. A third area of interest in functional materials is to provide structure or actuation that supports how the materials are deployed.

Functional materials are envisioned to support detection by amplifying the energy of the radiation interaction. A further potential purpose for novel materials is to act as a source of energy and power for the computational materials, including mechanisms to use the energy deposited by radiation for powering computational materials. In principle, nanostructured materials may be tailored to act as energy storage and power transducers.

Particles including photons can deposit kilo-electron volts to mega-electron volts of energy into a radiation absorbing material. The light yield and intrinsic efficiency is then related to conventional processes, such as for scintillators, to capture and transform this deposited energy into data measurements. However, there is potentially an ancillary method using nanoenergetic materials as a means of increasing the energy release per interaction event. This is analogous to the use of uranium in some hadron calorimeters to assist the measurement of total energy in complex sets of particle physics detectors. In this case, the fission process is a mechanism for enhancing energy available for detection and compensating for portions of a particle shower that may otherwise be lost. We are interested in a related research area that does not emphasize nuclear fission as a mechanism.

This example raises a question about lower energy detectors used in finding radiological or nuclear weapons and source emitters. Does the emergence of nanoscience open new pathways for accomplishing an energy enhancement in detection? We seek an emphasis on other means than fissionable materials as an energy source. A subarea for research is to explore materials for excitations other than solely scintillation/luminescence, and in the process investigate self-amplifying radiation sensitive material. Similarly, research could investigate semiconductors and composite materials with other types of self-amplifying functional centers for sensors.

Another research area that prompts consideration of energy amplification for detection is the growing field of investigation of tailored materials for energetic use. These include high energy density materials which can exceed tens of megajoules per kilogram, and which can lend themselves to rapid release of energy such as may be useful in propulsion applications. It may be possible to find novel mechanisms that can store energy and release power in a form useful for amplifying the signal from the direct deposition of energy by an ionizing particle in a detector.

Questions that may be answered include:

- What mechanisms on a nano (or micro) scale may be useful to accomplish enhanced energy per event for radiation detection?
- Can any of the known mechanisms in nanoenergetics provide sufficient energy that is released fast enough for detector response times?

- Are there energetic mechanisms that may be responsive to this need that are not well known?
- How does consumable energy release affect longevity of radiation detection material targets, or physical integrity of the detection component?

If there are suitable materials and physical mechanisms to augment measurement of a particle interaction, the next question is to determine whether the mechanism is a suitable alternative to current detector architectures. Would the same or better resolution be expected simply by adding a similar weight and volume of traditional radiation absorber instead of the energetic material? Deposition of MeV energy scales is equivalent to a large number of chemical-based augmenting interactions.

In addition to energy amplification, a functional material may transduce the output into a form specifically more useful for associated electronics. For example, the fit of photodetectors to a particular spectral region is a well-known issue in detector systems. What else might be done in a particular interactive material to couple the output and provide good signal-to-noise output for the rest of the detector? Questions that may be considered include:

- Can output from interactive materials be matched to the needs of supporting novel materials in a detector architecture (e.g., topological electronic materials)?
- Are there novel mechanisms within the interactive material for reducing noise or background?

A third area for investigation is the consideration of how materials serve to support deployment of sensors. Physically functional materials that explore order and active response to the environment in smart structures and materials may be for wide area, low intensity sensors and real-time image construction. For example, this subarea may serve to expand the potential for integrating sensing into mobile platforms such as unmanned aerial vehicles (UAV) or unmanned ground vehicles (UGV)/robotic platforms. Achievement in this area provides groundwork to advance the science of connecting function with structure in materials for nuclear sensing of weapons and materials or, more generally, nuclear threat detection purposes.

Another related area of interest for physically functional material research area is the exploration of wearable detectors, such as scintillating fibers that could be incorporated into body armor and uniforms, or hand-carried equipment with other primary functions than detection. Dosimeters are used for personal dose recording. The goal is to go beyond simple dosimeters and incorporate nuclear detector systems into wearable form. Transparent armor materials, for example, could be investigated to function as sensors or to match optical properties of scintillators.

Questions may include:

- What fundamental material architecture smart responses are suitable to explore for potential future deployment flexibility (e.g., can a sensing material be optionally rigid versus bendable, and how does this impact the sensing function)?
- Are there exploitable combinations of environmental stimuli and nanostructured materials responses, at either a local material level or across a macroscale, that alter the physical form of detector components in order to better improve measurement of ionizing radiation among various deployment options (e.g., wearable form factors may be very

different from UAV forms for detectors; also, flight conditions such as speed and altitude may impact the sensing area needed)?

RA1-FA4: Functional Computational and Electronic Materials

Silicon continues to dominate the market for ASICs, microprocessors, and microcontrollers with limited near-term potential for new materials that don't add functionality. There remain opportunities for adding new materials that add functionality or provide new approaches to computation. Research in this area should focus on radiation effects in emerging computational and electronic materials. While some materials and test structure development may be necessary, the bulk of the effort should focus on fundamental radiation effects, including but not limited to total ionizing dose, displacement damage, dose rate, and single event effects. Research in this area could include novel radiation induced failure mechanisms in novel or non-traditional materials or for materials operating in high-fields. It is expected that all research in this area will inform and be informed by modeling efforts at the material and device level.

One research area of interest is radiation effects in novel material systems with unique properties. This includes topological insulators and negative (differential) capacitance. Negative capacitance offers the possibility of beating the 60 mV/decade limit on FET subthreshold slope and enabling lower voltage/power computation. While some work has been done on radiation effects in ferroelectric materials, no known work has been done specifically on radiation effects on negative capacitance.

Another research area of potential interest is radiation effects in materials for non-charge based memory and computation. Spintronics and Valleytronics promise memory, computation, and communication approaches that don't rely on charge storage on transport. Recent studies have shown that spin lifetimes can be robust compared to electronic properties in GaAs after proton irradiation. For many material systems and test structures the possible effects of radiation are not yet known.

More established electronic and computational materials such as ultra-wide bandgap materials (Ga_2O_3, AlN, diamond, etc.) and perovskites are also relevant to this research area. Ultra-wide bandgap materials have higher breakdown voltages and are promising for applications in power switching and RF generation. Proposed research in this area should be informed by current radiation effects work on ultra-wide bandgap materials.

References for RA1-FA4:

Brennan C. Pursley, X. Song, R. O. Torres-Isea, E. A. Bokari, A. Kayani, and V. Sih, "Robustness of n-GaAs Carrier Spin Properties to 5 MeV Proton Irradiation," Applied Physics Letters 106, 072403 (2015)

Ando, Yoichi, "Topological Insulator Materials," Journal of the Physical Society of Japan, v82 issue 10, 2013.

Salahuddin, Sayeef; Dattat, Supriyo, "Use of negative capacitance to provide voltage amplification for low power nanoscale devices," Nano Letters, v8 Issue 2, pp405, 2008.

Khan, Asif Islam; Chatterjee, Korok; Wang, Brian; et al, "Negative capacitance in a ferroelectric capacitor," Nature Materials, v14 issue 2, pp182, 2015.

1.3.2. RA2: Devices and Integration. Individual materials or simple devices are rarely the end products of DoD applications. Understanding how these materials and simple devices interact with each other, and with ionizing radiation, is crucial to their implantation in DoD systems. For radiation detectors, the photodetector, signal amplification, and associated electronics have a significant effect on successful detection and discrimination. For complex logic and memory

electronics, the layout, access transistors, circuit design, architecture, and computation algorithm can determine which radiation effects are dominant and what impact they have on mission performance. RA2 is composed of four (4) FAs: FA1 – Photodetectors; FA2 – Non-volatile Memory; FA3 – Detector Electronics and Signal Processing; and FA4 – Non-traditional Computational Devices.

RA2-FA1: Photodetectors

Leveraging the active field of solar cell technology development has the potential to enhance photodetection capabilities for radiation sensing by increasing detection efficiency and accommodating flexible and scalable detector designs. This research area would pursue 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. Any proposed research should show how the proposed approach is competitive with state-of-the-art silicon photomultipliers (SiPMs). Research that investigates solid-state photodetectors and electronics could include exploring techniques that use flexible substrates; investigating organic materials, hybrid organic-inorganic materials, and perovskites with high quantum efficiency; exploring the possibility of organic photodetectors and scintillators polymerized at the same time.

RA2-FA2: Non-Volatile Memory

There is strong demand in both the DoD and commercial space for scaled high-reliability non-volatile memory. A number of different physical phenomena and technologies have been proposed for non-volatile memory including, but not limited to, phase change, ion and vacancy based resistance change, and magnetic tunnel junctions. There is also interest in one time programmable memory for security, trust, and high reliability FPGAs and multi-level cells that can reliably store more than one bit. Individual resistive elements have generally been shown to be resistant to total ionizing dose and displacement damage effects from radiation.

While research on non-volatile memory materials and individual devices is not excluded, this research area is particularly interested in the radiation effects challenges associated with scaling and integrating non-volatile memory. This includes radiation effects in selector materials, single event effects on arrayed non-volatile memory, and dose rate effects on memory arrays. Radiation effects on integrated one time programmable and multi-level cells is also of interest.

RA2-FA3: Detector Electronics and Signal Processing (Must be addressed in the draft IPP)

DTRA develops technology to search for, locate, and characterize radiological/nuclear (RN) materials and weapons of mass destruction. The detection of many materials, particularly Special Nuclear Material (SNM), is difficult due to weak radioactive signatures. In many cases, a close quarters search with portable detectors is necessary. In order to overcome these challenges, DTRA has been developing advanced detection systems, including wearable detectors, detector networks that provide improved situational awareness to warfighters, and unmanned vehicles (UAV, UGV) for autonomous searches. These detection systems require improved size, weight, and power (SWaP) in order to increase the speed, accuracy, and reliability of these searches. Additionally, decision makers are often flooded with sensor data simply because it can be provided. This information is often useless, and decision makers need more actionable information. Methods to automate information processing into meaningful and actionable information would be valuable for this mission space.

Improving the capabilities for radiological search relies on incremental improvements to detection system performance and its integration. Detector electronics and signal processing methods have been identified as an important research area with potential to improve the current detection capabilities of the aforementioned systems. Research related to signal processing, and detector electronics, should investigate innovative methods to improve the performance and integration of the non-detection components of a detector system. For example, relevant research may include the investigation of flexible electronics, which would provide some adaptability when mounting detection systems on non-traditional platforms. Additionally, novel integration of detector electronics with portable detection systems with a focus on improving SWaP would be a valuable investigation. Research may also include the exploration of integrated nano/microelectronics that could support the radiation sensitive material and the investigation of tailorable energy and power control for the detection system on the microscale. Similarly, the development of novel algorithms fits under this research area. Algorithm development aimed to improve detector performance, in both low and extremely high background environments, are of interest to DTRA. These algorithms could use machine learning and artificial intelligence or advanced statistical methods to analyze gamma spectra and extract valuable information.

Decision makers have access to record amounts of sensor data, but often this does not provide contextual information that could lead to informed action. Research to help provide context could focus on automating the processing of detector signals in order to efficiently and quickly transmit data and provide decision makers with actionable information. Research should be platform agnostic, but apply to systems where data from multiple sensors operate on a widespread network. The automation of information processing to provide context and decision making options is a significant need moving forward.

RA2-FA4: Non-traditional Computational Devices

As traditional digital Von Neumann computation begins to hit performance and cost limits, there has been increased interest in non-traditional and non-Von Neumann computational devices, approaches, architectures, and algorithms. Some approaches, such as distributed memory or multi-level devices, can be complementary to standard digital computation. Neuromorphic computation, analog computation, or computational memory approaches require new architecture and algorithms, but can be explored using CMOS devices and fabrication. Other approaches, such as quantum computing or all optical computing, require completely new devices, architectures, and algorithms. The effects of radiation on any of these non-traditional devices and approaches is relatively unknown and investigation requires an integrated modeling and experimental approach.

Research of interest in this area should consider the effects of radiation, not only at the device level, but at the circuit, architecture, and application level. It is known that SRAM and Flash memory can be the weak link in FPGA (Field Programmable Gate Array) or CMOS implementations of neuromorphic computing, or deep learning, and researchers are encouraged to look beyond effects on memory. In addition to total dose, displacement damage, and single event effects, researchers are encouraged to consider the effect of high dose rates on these systems.

1.3.3. RA3: Survivability and Response. As outlined in the National Defense Strategy, the priority of "transitioning from large, centralized, unhardened infrastructure to smaller, dispersed,

resilient, adaptive basing that include active and passive defenses," must be addressed to, "forward force maneuver and posture resilience." Research to prevent or reduce radiological contamination will allow the military to maintain battle rhythm while keeping troops and vehicles safe. With survivability, the science to protect soldiers, buildings, and equipment can help the military maintain a deterrence policy by ensuring the capability to respond to a nuclear explosion. Research into new radiation shielding materials and methods will aid in efforts to keep the warfighter and vulnerable equipment safe and able to work in extreme environments. Research in nuclear survivability testing is of particular interest as the DoD looks to modernize its strategic systems. New and faster methods for collecting and analyzing samples will assist in determining the characteristics of a nuclear blast in a way that better informs decision makers. This RA is composed of four (4) FAs: FA1 – Survivability Testing; FA2 – Collection and Analysis; FA3 – Radiological and Nuclear (RN) Contamination; and FA4 – Shielding.

RA3-FA1: Survivability Testing (Must be addressed in the draft IPP)

The DoD needs the ability to quickly and reliably test devices, components, sub-systems, and systems to ensure that they will survive the effects of a nuclear explosion. While there are multiple potential effects from a nuclear explosion, research in this area is primarily concerned with ionizing radiation. This includes neutrons, gammas, protons, and electrons from a total dose, dose rate, and single event effect perspective. This area is not expected to focus on x-ray blow-off or high altitude electromagnetic pulse (HEMP), but could include fundamental system agnostic research on system generated electromagnetic pulse (SGEMP). It is not always possible to test at threat level across the threat spectrum, and in modern systems it may not be possible to test all the possible state space. Therefore, experimental testing should be closely tied to relevant modeling and simulation effects to understand the relevant fundamental physics and provide predictive capabilities. Survivability testing research also includes the identification and characterization of novel radiation induced failure mechanisms.

One potential research area of interest is the broad area of equivalence and dose equivalence testing. Radiation test facilities can be expensive and in high demand, but don't necessarily replicate the threat energy or spectrum. The use of alternative energetic particles in radiation effects testing is routine and valuable, but the underlying physics can be different and the limits of equivalence are not known. This area includes but is not limited to proton equivalence for displacement damage, electrons, 14 MeV neutrons, pulsed lasers for single events and dose rate testing. Modeling and simulation of test radiation and threat radiation to understand the limits of equivalence would be expected in this area.

Another research area of interest is dose rate testing and modeling especially for emerging devices or commercial off the shelf (COTS) parts. With the increased interest in radiation hardening of strategic systems, there is an increasing need to understand and test emerging devices and designs for dose rate (prompt gamma). Research in this area needs to focus on fundamental effects and testing challenges; not in testing particular technology nodes or verifying particular parts.

There continues to be research interest in approaches to test and model highly integrated devices and systems-on-a-chip (SOC). The highly integrated nature of these devices presents unique challenges for testing, screening, and validating. Research should focus on fundamental challenges and innovative approaches, not on specific devices or technologies.

Research in this area could include innovative approaches to survivability testing, and source

development, focused on ionizing radiation or ionizing radiation testing equivalents. Research in this area is encouraged to be innovative, and forward looking, rather than modifying or improving current approaches or technologies.

The final area of interest in survivability testing, in connection with CCRI, is addressing the challenge of how much testing is necessary to accurately predict system survivability and mission performance. This is particularly of interest for COTS parts or highly integrated parts.

RA3-FA2: Collection and Analysis

DTRA invests in research and development (R&D) to provide the DoD the capability to collect and analyze post-detonation debris. DTRA also manages the R&D for new capabilities for monitoring nuclear proliferation activities.

After a nuclear detonation, the DoD will need information, and analysis capabilities, to properly assess the damage and risks which are inherent in a nuclear battlefield. The ability to collect data from field detectors, and to extract nuclear forensics from collected debris rapidly and accurately with high confidence, is critical to this effort. Current scientific methods are time consuming to provide this high quality data. Additionally, scientists may not be able to quickly analyze the complex gamma spectra that will be produced in a post-detonation nuclear environment. Areas of research interest include: understanding phenomenology that govern novel analysis methodologies; methodologies for compiling, assessing, and interpreting large sets of data; and understanding the treatment of data uncertainties.

This FA explores the improvement within the capability of sample collection after a nuclear event; 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.

Additionally, detectors that monitor radioactive gases must be improved to collect better data on adversary test performance. Current gas collection is performed using activated charcoal technology. Due to the rise of novel materials and substrates, there is an opportunity to use MOFs, zeolites, and carbon materials to decrease the minimum detection limits of radioisotopes of xenon and argon. Of particular interest, are materials with the ability to be reused for multiple detections and for materials that can be used as the absorbent and detector.

Research into machine learning, or more generally techniques derived from artificial intelligence science, that identifies isotopes from the large number of complex spectra with overlapping peaks can be explored. DTRA is also interested in the exploration of multi-mode detection summary reporting methods suitable for employment over long latency small bandwidth wireless communications links; one mode being a radiological signature.

RA3-FA3: RN Contamination

In 2011 the Fukushima-Daiichi incident led to the contamination of navy ships during Operation Tomodachi; the assistance mission to support Japan in disaster relief. Concurrently, the return of great powers competition has led to an increased chance of a nuclear detonation occurring. The U.S. Government has to be prepared to, “manage the consequences of a nuclear detonation,” as outlined by the Nuclear Posture Review (NPR). Significant contamination of military equipment, personnel, and vehicles is possible in a nuclear environment. Notably, Operation

Tomodachi showed that there are opportunities for research in areas such as materials science and modeling and simulation to help mitigate the effects that RN contamination has on the battlefield. Other technologies, that have been successful in other specialties, may provide solutions to problems encountered by the warfighter in a RN-contaminated environment.

This FA explores the use of methods, materials, or pretreatment to prevent or remediate RN contamination of DoD equipment and warfighters. In particular, research that investigates the behavior of RN contamination of air filters and oil-based lubricants, along with methods to remove or prevent contamination, is desired. Additionally, DTRA also seeks research on the behavior of RN contamination with Chemical Agent Resistant Coating (CARC) paint. Other areas include: active RN contamination prevention, exploration of new RN decontamination methods of equipment, RN contamination resistant materials, and investigations of the surface interaction of radioactive particles and materials.

Additional work that leverages research from other fields of remote detection (such as hyperspectral imaging, LIDAR, and radar) could possibly be applied to RN contamination detection. For example, research that explores methods to detect radioactive contamination on surfaces of objects, and in the air at long distances, is of interest. Additionally, research exploring methods for tracking radioactive debris, and dust, is of interest.

Near real-time computational analysis is also needed to provide the DoD situational awareness for RN threats on the battlefield. Proposed research could investigate data compression, and data security, for providing near real-time sensor data. Research in this area could include a focus on how to provide real-time data from networked radiation detectors and dosimeters to update deterministic models, including transmitting sensor data via non line of sight methods.

References for RA3-FA3:

Feickert, A., & Chanlett-Avery, E. (2011, June). Japan 2011 earthquake: US Department of Defense (DOD) response. Congressional Research Service, Library of Congress.

Patterson, J. S., Fauvell, K. D., McMahon, J., & Moralez, J. O. (2015, June). United States Navy 501-K34 Gas Turbine Engine RADCON Effort. In ASME Turbo Expo 2015: Turbine Technical Conference and Exposition (pp. V001T22A002-V001T22A002). American Society of Mechanical Engineers.

Hartig, Kyle C., Isaac Ghebregziabher, and Igor Jovanovic. "Standoff detection of uranium and its isotopes by femtosecond filament laser ablation molecular isotopic spectrometry." Scientific reports 7 (2017): 43852.

Bureaux, John G., George R. Cowan, N. Edward Cundasawmy, and J. Garfield Purdon. "Decontaminating and dispersion suppressing foam formulation." U.S. Patent 6,405,626, issued June 18, 2002.

RA3-FA4: Shielding

Across the shielding mission space there is a push to make the shielding lighter, thinner, cheaper, and multifunctional without sacrificing the level of protection. Each system has different shielding requirements: weight, cost, blast, kinetic, gamma, neutron, EMP, laser, electrical charging, and environmental resistance. Many current approaches to reduce shielding weight (carbon composites, honeycomb structures, ceramics, and polymers) are reducing the radiation protection factor. Operation in a radiological-nuclear contaminated zone requires protection against relevant ionizing radiation. Of primary concern, are high neutrons and photons (gamma and X-rays), which have different primary interactions and require different shielding strategies. To protect against high-energy gamma rays, a combination of low-Z and high-Z material layers are required to attenuate the energy by Compton scattering and photo-electric absorption. Similarly, multiple layers are required for the three step process to protect against high-energy

neutrons. The first step involves slowing the fast neutron by using high neutron cross-section materials and then absorbing the thermal neutron by the absorbing layer with high absorption cross-section material. Finally, the resulting gamma rays and x-rays are absorbed by a layer of high-Z dense material. This multi-layer approach makes the whole shielding system bulky and may not be suitable for transportable systems.

Nanocomposites and structured nanocomposites offer a promising approach to meet weight and manufacturing requirements without sacrificing protection from ionizing radiation. There are design opportunities and optimization schemes for shielding to provide a wide spectrum of protection in nuclear threat environments. An element such as hydrogen, with the high charge-to-mass ratio, provides high energy attenuation for neutrons, but is not a structural material. One neutron shielding approach is to incorporate a material with high hydrogen content, such as the polymer polyethylene. However polyethylene can be bulky, and may not have the required structural or durability properties for many DoD shielding applications. Polymers may be strengthened using micro or nanoscale additives or by forming nanocomposites. Hydrogen can also be bound to metals and nanotubes to improve the shielding effectiveness. Tungsten nanoparticles dispersed in polymer matrix and bismuth lead borate glass systems are promising for gamma ray shielding. The addition of high neutron cross-section elements such as boron, lithium, and gadolinium can absorb neutrons.

In addition to the development of multifunctional nanocomposite materials for shielding, this area is interested in approaches and methods for optimizing the shielding tradeoffs in multi-threat environments. While a single layer of composite shielding would be the most efficient solution, with respect to cost and manufacturability, there could be significant protection and weight advantages to the inclusion of higher ordered structures such as metamaterials, phononic crystals, or lattice structures.

References for RA3-FA4:

Shruti Nambiar and John T. W. Yeow, Polymer-Composite Materials for Radiation Protection ACS Applied Materials & Interfaces 2012 4 (11), 5717-5726

B.G. Frandsen, Gamma Radiation Shielding of Multi-Functional Composites. MS Thesis, AFIT/GNE/ENP. School of Engineering and Management, AFIT, WPAFB, OH, 2016.

T.B. VanHoose, X-ray Shielding Effectiveness of Multifunction Composite Materials. MS Thesis, AFIT/GNE/ENP, School of Engineering and Management, AFIT, WPAFB, OH, 2015.

Siyuan Chen, Polymer Based Nanocomposites as Multifunctional Structure for Space Radiation Shielding: A Study of Nanomaterial Fabrications and Evaluations, Doctoral Dissertation, Waterloo, Ontario, Canada, 2018.

1.3.4. Cross-Cutting Research Initiative (CCRI): Modeling and Simulation. Much of the experimental work in the three RAs is expected to inform and be informed by modeling and simulation efforts. Technical collaboration, peer review, and code sharing across the research topics and research area is expected to enhance the research outcomes. Models for radiation transport, energy deposition, device response, as well as circuit level compact models could inform multiple research FAs. Models for light propagation, dispersion, and collection also cross multiple FAs. This crosscutting component also encourages the transition of fundamental modeling results to higher order models. For example, the properties and radiation response of individual materials naturally transitions to higher order models for devices and circuits. Efforts could focus on addressing the scalability and compatibility between modeling codes such as GEANT and MCNP. Work should include approaches to finding overlap or synergy to improve

code reliability across many performance areas. Also, methods to shorten computation time for codes will be considered. Alliance members should be prepared to collaborate with other alliance institutions for code validation and experimental planning.

One research area of interest is the accurate modeling of the effects of radiation on the mission relevant performance of non-traditional computational systems, based on the effects of individual devices (including non-CMOS devices), circuits, and architectures.

Another potential research area of interest is the ability to comprehensively model the nuclear survivability of DoD systems. This includes the ability to incorporate material, device, or component level testing and modeling as well as predicting survivability based on limited test data.

Another research area could be the exploration of mathematical methods for speeding up Monte Carlo models of 3D passive images generated by neutron and gamma imagers. This cross-cutting research area could include the modeling of the interaction of radiation, light transport, and light collection in new scintillators.

1.4. Structure and Management

It is critical that the IIRM-URA be structured and managed to create and foster an open, collaborative research environment. This section describes a framework for the organization of the IIRM-URA. The lightweight framework is flexible to minimize overhead, yet ensure research relevance and proper oversight. Applicants can suggest additional management tools and mechanisms as part of the proposal, but in doing so they must also justify and demonstrate the benefit and cost effectiveness of these additional management activities.

DTRA and the IIRM-URA will collectively be referred to as the IIRM-Consortium. Other Government agencies may be invited to join the IIRM-Consortium and to contribute, as appropriate, their technical expertise, personnel, access to research facilities, and funding. Given that the research program may be enhanced during the lifetime of the CA, applicants should suggest a procedure for how the enhanced program may be considered and incorporated by the IIRM-URA.

The IIRM-URA will strive for a focused, yet flexible research environment. The IIRM-URA will be led by a single U.S. institution of higher education that will be designated as the LRO. The LRO will be charged with spearheading the focused basic research program and must have the ability to integrate the broad palette of research required to realize the goals of the IIRM-URA. Each RA will be led by a different LRAO; each LRAO will be a U.S. institution of higher education. One of the LRAOs could also be the LRO; however, the same entity cannot be the LRAO for more than one RA. It is expected that each LRAO will make significant scientific contributions to the respective RA and to the Alliance, as a whole. As such, DTRA anticipates that the LRO and the LRAOs will provide multiple PIs to work across the Alliance to create a matrix of PIs to address the research within the RAs. Together the LRO and LRAOs make up the permanent members of the IIRM-URA, who together are responsible for shaping and steering the Alliance through collaboration with DTRA. Collectively, the IIRM-URA members and DTRA make up the Consortium.

Performance under the CA will also include additional organizations (over and above the LRO and LRAOs) as non-permanent subawardees to round out the technical expertise and research tasks. Any such organizations are expected to be subawardees to the LRO and will be

considered as non-permanent members of the IIRM-URA. The non-permanent members of the URA may consist of U.S. and foreign institutions of higher education, DoD-Degree Granting Colleges and Universities, DoD Service Laboratories, FFRDCs to include DOE National Laboratories, U.S. industrial partners, and/or U.S. and foreign non-profit organizations to include UARCs possessing the required expertise. Given the likelihood that the non-permanent members will change over the lifetime of the CA, applicants should suggest a process for consideration and incorporation of new organizations into the research program.

Alliances are encouraged to include Historically Black Colleges and Universities and Minority Institutions defined 10 U.S.C. § 2362(e).

1.4.1. Technical Guidance and Oversight. The following framework is required for the management and oversight of the IIRM-Consortium. Applicants may propose additional plans or mechanisms for management; however, applicants are cautioned to ensure that any such plans or mechanisms are: (1) not duplicative of the requirements and (2) not overly burdensome to the Alliance. A description of each component of the IIRM-Consortium management follows:

- Cooperative Agreement Manager (CAM). The integrated scientific management and fiscal responsibility for the URA will reside with the DTRA Basic Research Manager, who will be designated the CAM for the IIRM-URA under the CA. The Grants Officer will receive recommendations from the CAM and will be the ultimate legal authority empowered to make formal modifications to the CA.
- Technical Points of Contact (TPOCs). The TPOCs are the government subject matter experts (SMEs) that are charged with the scientific stewardship of the RAs and CCRI. Each RA will have a DTRA TPOC. The TPOCs will work collaboratively to lead the CCRI efforts. The TPOCs will be heavily involved in the scientific management and review of the IIRM-Consortium. The TPOCs will have significant responsibilities in the development of the Initial and Biennial Program Plans (IPP/BPP); fostering deep and persistent multidisciplinary research across the RAs; and performing day-to-day administrative duties associated with the RAs. The TPOCs will be the advisors to the CAM.
- Lead Research Organization (LRO). The LRO provides the overall research leadership for the Consortium. This responsibility includes the day-to-day management of the IIRM-URA; oversight of the development of the IPP/BPP; participation in the research; promoting collaboration and technology transition; distributing Government funding to permanent and non-permanent members of the Alliance; and maintaining proper research invoicing. The LRO will designate a Program Manager (PM) from their organization who will be the Alliance's scientific and programmatic representative charged with providing management and guidance of the CA. The level of research funding for the LRO should be determined by the planned research in the IPP or BPP. DTRA does not intend for the level of research funding for the LRO be consistent from year to year or that research funding be evenly divided among the LRO and LRAOs.
- Program Manager (PM). The IIRM-URA PM is the LRO's scientific representative charged with the Alliance's overall responsibility for management and guidance of the CA. The PM is required to be an eminent scholar in the field of physics, materials science, engineering, or computer science and have the stature, experience, and leadership skills to successfully execute the IIRM-URA. It is also recognized that the

PM may require support to manage and execute the CA, and this support should be included in the proposal submission. This support could include an Alliance administrator, faculty support, or staff support.

- Lead Research Area Organizations (LRAOs). LRAOs provide research leadership for a specific Research Area (RA). This responsibility includes supporting the PM in the development of the IPP/BPP; creating and fostering deep and persistent multidisciplinary research across the RAs; performing day-to-day administrative duties associated with the RAs; and conducting fundamental research in support of the IIRM-URA. Each LRAO will identify a specific Research Area Lead (RAL) to represent the LRAO in Consortium planning and execution and to serve as a member in support of the PM and CAM during TMG meetings. If the LRO is also a LRAO, the PM and the RAL must be different individuals. The level of research funding for the LRAOs should be determined by the planned research in the IPP or BPP. DTRA does not intend for the level of research funding for a LRAO be consistent from year to year or that research funding be evenly divided among the LRAOs.
- Technical Management Group (TMG). The TMG is chaired by the CAM and consists of the PM, the three RALs, the corresponding RA Government TPOCs, and other senior DTRA scientific personnel as deemed appropriate by the CAM. The TMG will collaboratively lead the Consortium and assist the CAM and the PM in carrying out their duties concerning the IIRM-URA. The RALs and the corresponding RA Government TPOCs will collaboratively lead the RAs through the TMG. The TMG will be responsible for the management and integration of the Alliance's efforts including programmatic, technical, reporting, financial, and administrative matters. In matters where a consensus cannot be reached amongst the TMG, the CAM will have final decision-making authority. The TMG makes recommendations that concern the membership of the Alliance, the definition of the tasks and goals of the participants, and the relative distribution of funding to the members and non-permanent subawardees. The TMG will meet at least quarterly.
- Research Management Board (RMB). The RMB will be established by the CAM to identify and develop collaborative opportunities, advise and assist the CAM in setting research goals by providing advice into the BPP planning process, provide recommendations to the CAM for the option year execution, and facilitate transition of URA research to basic and applied research programs. The RMB will be chaired by the CAM and other senior DTRA scientific personnel as deemed appropriate by the CAM, the TPOCs and other representatives from DTRA, as appropriate. Other service organizations and other Government agencies with interest and expertise in the technologies related to the IIRM-URA may also be included at the discretion of the CAM. The RMB will be invited to the Technical Review and appropriate workshops. The RMB will also be invited to provide feedback on the IPP and BPPs.

1.4.2. Articles of Collaboration (AoC). The AoC define the operational structure and governance within the Alliance including:

- Membership and management
- Changes to Alliance membership

- Financial, personnel, facilities, and reporting requirements
- Intellectual property
- Information exchange guidelines
- Modifications to the AoC

Applicants invited to submit a proposal will be provided with a model AoC, along with their invitation to submit a proposal. The model AoC represents appropriate and necessary terms and conditions that the Government finds acceptable for operation of the IIRM-URA. Applicants must submit the AoC with the proposal signed by a duly authorized representative for each proposed member of the Alliance. The model AoC can be executed by the proposed members of the Alliance "as is" or changes can be proposed. If changes are proposed, applicants are hereby informed that justification of any changes should be included with the proposal and such changes must be acceptable to the Government for the applicant to be eligible for award.

1.4.3. Initial Program Plan (IPP). Within 90 days after award, the PM will prepare an IPP through the TMG to cover the following nine-12 months of performance. The IPP will be based substantially on the draft IPP submitted as part of the proposal from the Alliance. The IPP should provide a detailed description of well-coordinated research activities. The IPP will contain a Data Management Plan as an appendix. The IPP will take into account the level of funding for the first year, including any ramp in funding. DTRA acknowledges that large alliances can take significant time to implement and not all subawards will be in place by the start of the IPP.

The IPP should be accompanied by a nine-year roadmap that describes the overarching goals and objectives to be accomplished by the Alliance within the Consortium structure. This roadmap should provide the vision for goals to be addressed during the first five years of the Alliance and similar for the two additional two year option periods. It should provide approximate timelines for research activities to facilitate potential future basic research transitions.

The IPP and the roadmap will be submitted to the CAM for review and approval. The final, approved IPP will be submitted to the Grants Officer for incorporation into the CA.

1.4.4. Biennial Program Plan (BPP). Nine to 12 months after award, the PM will prepare a proposed BPP through the TMG for the next two fiscal years. The BPP will enable integration and execution of multidisciplinary, collaborative research that strives to achieve URA objectives.

The BPP will provide a detailed plan of research activities (including research goals, key personnel, collaboration opportunities, staff and student development opportunities, facilities, experiments and budget) that commits the Alliance to use their best efforts to meet specific research objectives. The BPP will also describe the collaborative efforts with the Government. The BPP will include a detailed description of the projects proposed to be undertaken by any non-permanent subawardees, including new non-permanent subawardees. The BPP will contain the Data Management Plan as an appendix.

The BPP will be submitted to the CAM for review and approval. The final, approved BPP will be submitted to the Grants Officer for incorporation into the CA. This process will continue through the life of the CA. Each BPP will cover a two-year timeframe, but may be altered, with the approval of the CAM and the Grants Officer, if research work requirements change.

During the course of performance, if it appears that research goals will not be met, the TMG will provide a proposed adjustment to the BPP for approval by the CAM. In addition, the CAM may from time to time request that additional research be added to the BPP within the scope of the CA. The Alliance, as an entity, will not solicit or accept funding from outside sources other than DTRA without the approval of the CAM and the Grants Officer.

During the course of performance, the Grants Officer, in coordination with the CAM, will have approval authority for certain specific changes to the IPP/BPP including but not limited to:

- Changes in the scope or the objective of the program, IPP/BPP, or research milestones;
- Change in the key personnel specified in the IPP/BPP;
- The absence for more than three months, or a 25% reduction in time devoted to the project, by the PM;
- The need for additional Federal funding; and
- Any subaward, transfer, or contracting out of substantive program performance under an award, unless described in the IPP/BPP.

1.4.5. Annual Technical Review Meeting. Each year, the IIRM-URA must conduct a Technical Review that is open to the scientific community at-large where the research portfolio is presented by the PIs. Such a review is intended to allow the Alliance researchers to engage in face-to-face technical discussions as well as garner input on the technical achievements of the Alliance from the broader community. One goal of this meeting is to foster interactions and collaborations among researchers and allow Consortium research leadership to assess research progress. The emphasis for the review is on collaborations (especially multi-disciplinary, cross-RA collaborations), experimentation/validation plans, and possible transition opportunities.

Planning for the annual Technical Review Meeting will be conducted by the TMG. The annual Technical Review Meeting will be executed by the Alliance. A hosting rotation between the permanent Alliance members is encouraged.

DTRA strongly encourages student and post-doctoral fellow participation in the annual technical review meetings. It is, however, recognized that such participation must be balanced with the associated costs. Thus, DTRA anticipates that a significant number of the students and post-doctoral fellows will participate in each review. DTRA also anticipates that the Alliance will consider site rotation and inclusion of more advanced research in selection of student and post-doctoral fellows for review participation. To ensure development of student and post-doctoral fellows the review must include targeted avenues for them to accomplish collaboration and networking and share their research, e.g., through poster presentations or oral sessions.

Applicants should suggest a model with an associated cost for the conduct of annual reviews of the research program that meet the intent of what is described herein.

1.4.6. Additional Information. It is anticipated that the Alliance will participate in other DTRA program reviews.

The IIRM-URA, as an entity, will not solicit or accept funding from outside sources without the approval of the CAM and the Grants Officer.

The CAM, in coordination with the RMB and DTRA leadership, will be responsible for

integrating the IPP/BPP into the overall Government research and technology programs. During the course of performance, the Grants Officer, in coordination with the CAM, will have approval authority for certain specific changes to the CA including, but not limited to:

- Changes to the AoC if such changes substantially alter the relationship of the parties as originally agreed upon;
- Solicitation or acceptance of funding under the agreement from sources other than DTRA; and
- Changes in non-permanent Alliance membership, if not documented in the IPP/BPP.

1.5. Collaboration and Workforce Development

Persistent collaboration across the IIRM-URA will enhance innovation and have a high return on investment. Creation of an environment that is conducive to collaboration is a critical element in establishing the Alliance. It is DTRA's strong belief that work conducted under the IIRM-URA cannot be successful either in whole or in part without this collaboration. Further, collaboration across the Consortium is also integral to the execution and success of the program. DTRA views the Student Pipeline Development effort to be the most important of the Collaboration and Workforce Development Activities.

1.5.1. General Activities. The URA is encouraged to hold regularly-scheduled scientific lectures, conduct short courses, convene RA-focused technical meetings, and technical workshops on mutually agreed upon topics throughout the period of performance. Additionally, the IIRM-URA is expected to hold regular, periodic research reviews that will permit and encourage the free exchange of ideas and research results, especially those impacting any crosscutting research themes. Alliance PIs may be invited to give a seminar at DTRA up to four times a year for the duration of the CA. Likewise, DTRA personnel may give seminars at Alliance locations. Importantly, these activities should include opportunities for junior faculty and junior staff researchers, students, and post-doctoral research fellows to participate in a meaningful way. The activities will: serve as educational opportunities for all Alliance members, including students and post-doctoral research fellows; provide additional collaboration opportunities; and provide a mechanism for inclusion of the broader community of interest. Thus, consideration should be given to involvement of participants outside the Alliance when appropriate.

1.5.2. Student Development. Applicants may consider concentrated efforts for development of students and post-doctoral research fellows as part of the Alliance efforts. Such concentrated efforts are in addition to the typical developmental activities that occur in the normal course of university research.

1.5.3. Student Pipeline Development. The IIRM-URA is expected to establish a program to foster long-term (one year or longer), meaningful collaborations between high school and/or undergraduate students and relevant subject matter experts within the Alliance. The Alliance is encouraged to focus on IIRM-URA mission relevant areas that have high student interest, such as small unmanned systems. The Alliance could consider sandbox competitions for students that are based on experimental mission requirements of ionizing radiation and materials and small unmanned systems, taking care not to focus on platform development. Initially, DTRA anticipates that at least ten individual groups could be cultivated with a mid-term down-select in the total number, and culmination of the program with a demonstration of results. Participation

could be limited to high school or undergraduate students or blended groups could be considered. DTRA could envision a program that sponsors high school students to complete a summer internship at a university or a program with recurring school year based interactions. DTRA could also envision a program focused on undergraduate student projects. Care should be taken to structure the program such that the predominance of funds are used for Alliance SME contributions and equipment and supplies for the students. DTRA anticipates that over the lifetime of the CA this program would evolve. Other models and variations may be suggested. This program should not be primarily focused on traditional high school or undergraduate research on IIRM-URA funded projects.

While student pipeline development activities are not required to be directly connected to the ongoing technical research efforts, there is the potential for these student activities to have a direct tie to the research efforts. For example, well designed student competitions could be used to generate novel ideas or test competing approaches. Student activities could also be an avenue for functional or mission focused testing.

Potential activities could include combining COTS radiation sensors with COTS unmanned systems for experimentation and verification of theory for path planning and navigation. One of the primary goals of this kind of outreach would be to expose the RN search SMEs to the autonomous/unmanned systems SMEs.

Another potential activity could include novel approaches to transfer data (maybe radiation sensor data) from COTS unmanned systems to a laptop or cell phone or tablet or another unmanned system. Of particular interest would be data transfer in challenging environments (inside buildings, high noise, short transmission windows) without the use of existing networks.

Further potential activities could include on-orbit or high altitude radiation effects measurements, radiation tolerance or avoidance approaches for terrestrial unmanned systems for emergency response or automated debris sampling.

Other potential activities could include novel approaches to radiological decontamination of unmanned systems or autonomous approaches to tracking/mapping/characterizing radiological contamination and plumes.

1.5.4. Staff Rotations. An important element of IIRM-Consortium collaboration is the advancement, education, and rotation of technical staff through short- and long-term temporary assignments across the Alliance and at DTRA. The scope of this collaboration may range from regular, periodic short-term visits to sabbaticals lasting as long as a year. Staff rotations will be undertaken to foster and facilitate collaborative research where face-to-face interaction is advantageous, to enable a researcher to utilize unique facilities, to enable Alliance personnel to obtain specialized training or experience and to facilitate the exchange of research results. There should be a balance of staff rotations across all the partners in the Alliance and across all the research areas. Student and post-doctoral research fellow participation in staff rotations is strongly encouraged.

In addition, this exchange of personnel will provide Alliance personnel with insight into DTRA-unique requirements and will provide Government personnel with insight into IIRM research and/or the opportunity to pursue fundamental research with noted researchers.

All salary and travel costs associated with a rotation of Government personnel will be borne by the Government. All salary and travel costs associated with staff rotations of Alliance members

will be funded under the CA or may be provided by the Alliance member as a cost share; it is anticipated that some portion of the Alliance's scientific labor-years will be in staff rotations.

1.5.5. Electronic Resources. The Alliance is expected to host a web-based repository of information from the IIRM-URA that is accessible by Consortium stakeholders for the duration of the IIRM-URA CA. This repository will include programmatic and review material. It will also serve as a vehicle for software and dataset sharing. As such, applicants should note the requirement for a Data Management Plan to be developed as part of the IPP process, and revisited through the BPP process. Upon completion of the CA, it is expected that end-to-end documentation will be delivered to the Government for record keeping, e.g., technical review materials, meeting minutes, reports, etc. Applicants should also consider other electronic and web-based avenues to promote the Alliance to the larger community of interest. Minimally, DTRA anticipates that the Alliance will publish and distribute a newsletter at least annually detailing research results, technical impacts, and collaboration activities.

1.5.6. Other. While primary paths for the collaboration with DTRA will be through the TMG, the IPP/BPP process, the annual technical review meeting, and activities suggested herein, applicants are strongly encouraged to suggest additional new and innovative avenues for fostering collaboration within and external to the Consortium. The costs associated with these activities will be funded under the CA.

1.6. Enhanced Program

Should the IIRM-URA be of interest for DTRA Budget Category 6.2 funding (Applied Research funding) or to other funding agencies, an unfunded Enhanced Program is included in this BAA. This is intended to provide a mechanism for growth and enhancement within the URA. DTRA and/or other Government agencies may choose to support the program with basic and/or applied research dollars in areas of specific interest to their basic and applied mission programs. This enhanced program will leverage parallel and/or transition the research, technology and capabilities that are the core of the DTRA funded URA. Applicants are not to include the Enhanced Program discussion in the Phase I pre-proposal submission. Applicants invited to submit a Phase II proposal should include a general discussion of possible ways to develop and source Enhanced Program projects.

1.7. Program Metrics

DTRA anticipates that the IIRM-URA performance metrics will include items like the following: technical accomplishments, the number and quality of refereed journal and conference articles, invited presentations, patents and inventions, sponsored workshops and seminars, students supported, student graduations, awards, and staff rotations. Metrics on the success of the collaborative student pipeline development could include the number of students, the length of the interactions, student turnover rates, and student accomplishments. The success of the interaction and collaboration portion will be assessed by the quality of the collaboration as demonstrated by joint efforts such as multi-PI journal articles, shared models and databases, multidisciplinary workshops, and self-reported successes.

2. FEDERAL AWARD INFORMATION

2.1. Award Types

DTRA anticipates that a single CA may be made from this BAA. The Government actions under this BAA shall adhere to the requirements of 2 CFR Part 200, as modified and supplemented by DoD's interim implementation found at 2 CFR Part 1103 and the DoD Grant and Agreement Regulations (DoDGARs).

The Government reserves the right to fund all, some, or none of the proposals submitted; may elect to fund only part of any or all proposals, and may incrementally fund any or all awards under this BAA. An award may be made to the Alliance that offers the best value to the Government. Applicants must recognize and understand that there are no guarantees any award will be made or, if an award is made, that it will be for the levels of funding detailed in Table 1. The Government also reserves the right to request applicants make any changes necessary to submitted full proposals to increase the feasibility of making the proposal fundable. Applicants may decline to participate in any revisions to application packages requested by DTRA. Alliance members may be expected to compromise and sacrifice anticipated funding to their organization as necessary and appropriate to meet the goals and objectives of the IIRM-URA as established through the collaborative planning process.

2.2. Subawards

Subawards are an integral part of the Alliance. The LRAOs will be subawardees to the LRO. This permanent Alliance membership will be augmented with non-permanent subawardees to meet the research objectives of the IIRM-URA, especially for the conduct of new and innovative niche research for which they are particularly qualified. Non-permanent subawardees are organizations that (1) are not expected to provide strategic input concerning the goals and direction of the IIRM-URA and (2) may have a long or short-term relationship with the Consortium, as defined by the IPP/BPP and overall Alliance strategy/roadmap. The non-permanent subawardees may change over the lifetime of the CA. Care should be taken to ensure that the non-permanent subawardee involvement is meaningful and, where appropriate, consistent with graduate student development and education.

The LRO will distribute the funding to each LRAO and non-permanent subawardees.

2.3. Award Values

The CA may range from $5M to $6M annually (total, including both direct and indirect costs) depending on the nature and the scope of work. The funding includes all known costs associated with the CA, i.e. the costs for research, program management, experimentation, travel, outreach, collaboration, workforce development, etc.

All awards are subject to the availability of funds. Additional guidance regarding award values may be provided in invitations to submit a Phase II application package. Any specific guidance provided to an applicant supersedes the information provided herein. Funding for participation in this program is highly competitive and the cost of proposed research should strictly be maintained as detailed herein or as indicated in the invitation instructions.

2.4. Period of Performance and Award Structure

Any CA resulting from this BAA will be awarded for a five-year base period. There will be two options to extend the CA for an additional two years each. The total potential period of

performance under the CA will be nine years.

Prior to the end of the fourth year, a comprehensive program review will be conducted as directed by DTRA. This review will consider cumulative performance metrics, the Consortium's vision for each of the option periods of performance (to be submitted by the Consortium prior to the end of the fourth year), funding availability and the current research needs and goals of DTRA. The decision as to whether to exercise the first option is expected to be based on the results of the base period review and evaluation described above. A similar process will be followed for the second option period.

2.5. Hardware and Software

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

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3. ELIGIBILITY INFORMATION

3.1. Lead Research Organization (LRO)

With the requisite Letter of Intent (LoI), Phase I and Phase II application packages submitted in response to this BAA will be considered from accredited U.S. degree-granting colleges, universities, and academic institutions. The URA must be led by a U.S. institution of higher education with doctoral-level courses of study in scientific and research areas related to the effects of ionizing radiation in matter, such as physics, engineering, materials science, or computer science that can result in the granting of a doctoral degree. It is anticipated that multiple PIs from the LRO will be directly involved in Alliance research. This organization will be designated as the LRO and will have specific leadership and management responsibilities, including but not limited to the following:

- The LRO is expected to articulate a vision for the IIRM-URA, promote collaboration among Consortium members, and coordinate crosscutting research themes.
- The LRO is required to administer the IIRM-URA, participate in the research, and promote the transition of research and technologies resulting from the research program.
- The LRO is responsible for distribution of Government funding to Alliance members and non-permanent subawardees in accordance with the approved IPP/BPP. The LRO is also responsible for timely billing (invoicing) of executed research for itself and the other Alliance members to ensure proper disbursement of Government funds.

3.2. Lead Research Area Organization (LRAO)

Each RA will be led by a different LRAO, one of which may also be the LRO; the same entity cannot be the LRAO for more than one RA. Each LRAO must be an accredited U.S. degree-granting college, university, or academic institution. Each must possess substantial experience and expertise in the associated RA. Further, it is anticipated that multiple PIs from an LRAO will be directly involved in Alliance research across the RAs/FAs. Institutions of higher education are expected to have doctoral level courses of study in scientific and research areas related to this URA that can result in the granting of a doctoral degree.

3.3. Non-Permanent Subawardees

U.S. and foreign institutions of higher education, DoD-Degree Granting Colleges and Universities, DoD Service Laboratories, FFRDCs to include DOE National Laboratories, U.S. industrial partners, and/or U.S. and foreign non-profit organizations to include UARCs may be considered as non-permanent subawardees. Unfunded collaborations with foreign non-profits or governmental research organizations will be considered.

3.4. Limits to Alliance Membership

DTRA anticipates that an optimally sized consortium, to include the non-permanent subawardees, would include at least six organizations at a time. Phase I pre-proposals and invited Phase II proposals should provide a rationale for the proposed members and plans for changing the non-permanent subawardees.

DTRA anticipates that not more than 50% of the direct dollar value of the effort annually will be maintained at the LRO. DTRA also anticipates that if the LRO is not also a LRAO a minimum of 15% of the research dollars of the effort annually will be maintained at the LRO. DTRA anticipates that researchers from the LRO and LRAOs will participate in the research undertaken across the RAs.

Applicants should note that DTRA expects that a minimum of 70% of the total dollar value of the effort annually must be dedicated to participation of accredited U.S. degree-granting colleges, universities, and academic institutions. Thus, applicants are expected to consider carefully the construct of their proposed Alliance and effectively engage the appropriate membership and non-permanent subawardee performance to achieve the goals of the consortium as detailed in this BAA.

Allocation of any funds received via the enhanced program will be considered on a case-by-case basis.

3.5. Cost Sharing or Matching

Cost sharing is not required under this BAA; however, efforts that include cost sharing or in kind contributions from the non-degree granting partners are encouraged. During the evaluation of proposals, any cost sharing or in kind contributions will be evaluated as it relates to the evaluation factors listed in the BAA, based on the degree to which the proposed cost sharing or in kind contributions enhance the proposal to result in added benefits to the IIRM-URA. To allow for evaluation of a proposed cost sharing or in kind contributions, a proposal should express a firm commitment to provide such cost share or in kind contributions and evidence a process for integrating the same into the collaborative research program.

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4. APPLICATION AND SUBMISSION INFORMATION

4.1. Address to Request Application Package

This announcement contains all information required to submit a LoI, Phase I pre-proposal package, and an invited Phase II proposal package. The required application packages for Phase I and invited Phase II submissions are posted with this announcement. The application packages posted to www.grants.gov consist of the forms as detailed in Table 1.

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

Table 1: List of forms in the Phase I and Phase II application packages. The instructions for completing each of these forms may be found online at the following web link: http://www.grants.gov/web/grants/form-instructions.html.

4.2. Content and Form of Application Submission

Submissions for this BAA will be conducted in two phases; however, applicants must submit a non-binding LoI to be considered eligible to submit a Phase I package. Phase I is for receipt of pre-proposal submissions. Phase II is for receipt of invited proposal packages. Invitation to submit a Phase II proposal will be based on the evaluation results of the Phase I pre-proposal submission.

The LoI is required; however, it is not legally binding and does not enter into the review of Phase I or Phase II packages. The information in the LoI will allow DTRA to estimate the potential review workload and plan for the review. Prospective LROs must submit a LoI to the email address in Section 7 (only the LRO should submit the LoI, and it should cover the whole of the team). The LoI should minimally include the following information:

- Identification of the LRO and the LRAOs
- Name, address, and email address of the IIRM-URA PM
- Names and associated affiliations of other known key personnel
- A list of participating institutions known at the time of the letter preparation
- Number and title of this BAA.

4.2.1. Electronic Submissions. Phase I and Phase II packages and attachments **must be** submitted electronically using www.grants.gov and the corresponding application packages linked with this BAA on www.grants.gov (under the "Packages" tab). All applications, including all supporting documents, must be submitted in the English language.

Applicants are responsible for ensuring compliant and final submission of their Phase I and

invited Phase II packages. Note that this also applies to applicants using third party systems to submit application packages and attachments. Pre-proposal and proposal submissions that are not compliant will not be further evaluated.

4.2.2. Phase I Pre-Proposal Submission. Each Phase I application package contains the forms detailed in Table 2.

Form	Attachment	Action
SF-424 (R&R) Application for Federal Assistance Form	N/A	Enter the appropriate information in data fields
Research & Related Senior/Key Person Profile Form (Expanded)	PM Biographical Sketch	Attach to Biographical Sketch field
	PM Current/Pending Support	Attach to Current & Pending Support field
	Key Personnel Biographical Sketch(es)	Attach to Biographical Sketch field for each senior/key person
	Key Personnel Current/Pending Support	Attach to Current & Pending Support field for each senior/key person
Attachments Form	Attachment 1 – Project Summary/Abstract	Upload as Attachment 1
	Attachment 2 – Technical Narrative	Upload as Attachment 2
	Attachment 3 – Structure and Management Plan	Upload as Attachment 3
	Attachment 4 – Collaboration and Workforce Development Plan	Upload as Attachment 4
	Attachment 5 – Quad Chart	Upload as Attachment 5
	Attachment 6 – Cost Summary Tables	Upload as Attachment 6

Table 2: Phase I Application Package Forms and Attachments.

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

- Block 1 – Type of Submission. Applicants should indicate the Phase I submission is a "Pre-Application."
- Block 2.1 – Applicant Identifier. Not applicable.
- Block 3 – Date Received by State. Not applicable.
- Block 3.1 – State Application Identifier. Not applicable.
- Block 5 – Applicant Information. You must provide a Business Office Point of Contact (BPOC) with an e-mail address.
- Block 19 – Authorized Representative. The "signature of AOR" is not an actual signature and is automatically completed upon submission of the electronic application package. Hard copies or email attachments of applications will not be accepted.

Research and Related Senior/Key Person Profile Form (Expanded): The Research and Related Senior/Key Person Profile Form (Expanded) should be completed in its entirety for each of the

individuals who will be involved in a significant way in the research and management of the Alliance, e.g. IIRM-URA PM, RALs, PIs, and Co-PIs.

DTRA does not have a preference for the format of the biographical sketch. Biographical sketches shall be limited to three pages for the key leadership personnel, i.e., the IIRM-URA PM and the RALs. DTRA anticipates that for the IIRM-URA PM the submitted information will provide evidence of successful leadership of collaborative research.

Submission of biographical sketches for additional key personnel, e.g., PIs and Co-PIs, is required, but they must be limited to two pages per individual. Applicants should take care to only submit biographical sketches for participating individuals and include non-permanent subawardee PIs/Co-PIs.

Credentials, as documented on the biographical sketches, must include, among others, a record of seminal publications in the scientific literature with a citation index and a record of successful research in areas relevant to the IIRM-URA. Collectively, the biographical sketches must demonstrate how the aggregate of skills/expertise across the Alliance provides the required breadth and depth to effectively carry out the proposed program of research.

Additionally, a statement of current and pending support must be provided for each of the key personnel. This statement should include a summary of the current and pending support of related work and requires disclosure of all grants and contracts through which each IIRM-URA PM, RALs, PIs, and Co-PIs is currently receiving or may potentially receive financial support.

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

Attachment 1 – Project Summary/Abstract. The uploaded project summary should be less than three pages and provide a summary of the URA team, research program and collaboration plans. The abstract should not contain any proprietary data or markings.

Attachment 2 – Technical Narrative (limit 25 pages, including references). The technical narrative should include an overview of the research strategy to be employed to advance the state-of-the-art in understanding and controlling the interaction of ionizing radiation in matter; a short description and justification of the research goals for the proposed effort (for the base period and for each additional option); and a short technical discussion stating the background and objectives of the proposed research, the overall technical approaches to be pursued, the potential techniques to be used to validate the models and theories developed in this URA. This technical discussion should include a proposed breakdown of research tasks and short description of the technical approaches for each task. The technical narrative should outline which FAs will be addressed in the IPP. A discussion on the relevance of the research, strategy for validation of models, and linkages between research in the RAs and CCRI should be included. Where the technical narrative proposes research topics outside the scope described in this BAA, justification for such variance is required. The technical narrative should clearly identify specific scientific challenges and research barriers that relate to fundamental understanding and control of the effects of ionizing radiation in matter to solve problems related to radiation detectors, survivability of DoD systems, and military functionality following a nuclear event. The technical narrative should clearly highlight the innovations proposed and how they may lead to substantial advances in foundational understanding of the interaction of ionizing radiation and matter and highlight how the proposed research is expected to feed, be fed by, or in some other

way link with, research being performed elsewhere within the consortium. This only covers the core research program and its funding—no discussion of the enhanced program should be included.

Attachment 3 – Structure and Management Plan (limit 5 pages). The Structure and Management Plan must include a summary of the overall plan for leadership and management of the consortium. The Structure and Management Plan must include the identification of the PM, LRAOs (including RALs), and key leadership personnel with an overall plan for leadership detailing efficient management of the IIRM-URA Program. The Structure and Management Plan should also detail non-permanent subawardees. The Structure and Management Plan should demonstrate how the proposed URA will create an effective collaborative environment. The Structure and Management Plan must describe an overall strategy for adjusting the research plans in response to research insights gained, advances in the state of the art, and new collaboration opportunities.

Attachment 4 – Collaboration and Workforce Development Plan (limit 5 pages). The Collaboration and Workforce Development Plan should include general information on previous successful relevant collaborations and general plans for how researchers will collaborate within each RA and between RAs and how this collaboration will result in outcomes and further the goals of the URA. The Collaboration and Workforce Development Plan should include a summary of collaboration plans (processes and supporting toolsets), synergies gained from these collaborations, and examples of how researchers have successfully collaborated in the past. The Collaboration and Workforce development plan should address the general activities, student sandbox, staff rotations, electronic resources, etc. detailed in Section 1.5. The Collaboration and Workforce development plan should include the initial student pipeline development plan.

Attachment 5 – Quad Chart. The quad chart must be presented on one (1) page. The quad chart must not contain any proprietary data or markings. The quad chart must be provided in landscape layout.

Attachment 6 – Cost Summary Tables. For the Phase I pre-proposal only, two cost estimate tables shall be provided to communicate a broad idea of the participant's relative level-of-effort for the core program funding only. This information will be used in the evaluation of the research program. The first table should list the estimated **first year** funding by organization for each RA (see Table 3). A column for "Other" can be used for management or other costs. The final line is to be used for an estimate of costs across the RAs addressing the CCRI. The second, should list the estimated funding per organization for each of the five years (see Table 4).

Organization	RA1	RA2	RA3	Collaboration & Workforce Development	Other	Total
LRO						
LRAO-A						
LRAO-B						
LRAO-C						
LRAO-N						
Subawardees						
CCRI Portion						

Table 3: Year 1 Budget Estimates by RA/CCRI ($K)

Organization	Year 1	Year 2	Year 3	Year 4	Year 5	Total
LRO						
LRAO-A						
LRAO-B						
LRAO-C						
LRAO-N						
Subawardees						
CCRI Portion						
Collaboration & Workforce Development						
Total	$5M					

Table 4: Five Year Budget Estimates ($K).

4.2.3. Phase II Proposal Submission. Each Phase II application package contains the forms detailed in Table 5.

Form	Attachment	Action
SF-424 (R&R) Application for Federal Assistance Form	N/A	Enter the appropriate information in data fields
RR Budget Form	Budget Justification for each base and option performance period	Attach to Section K "Budget Justification" in budget period one
RR Subaward Budget Attachment(s) Form	Individual subaward budgets	Attach a separate budget with justification for each subaward
Research & Related Senior/Key Person Profile Form (Expanded)	PI Biographical Sketch	Attach to Biographical Sketch field
	PI Current/Pending Support	Attach to Current & Pending Support field
	Key Personnel Biographical Sketch(es)	Attach to Biographical Sketch field for each senior/key person
	Key Personnel Current/Pending Support	Attach to Current & Pending Support field for each senior/key person
RR Personal Data Form	N/A	Enter the appropriate information in data fields for all PIs/Co-PIs
Research & Related Other Project Information Form	Publically Releasable Proposal Summary/Abstract	Attach to Block 7 "Project Summary/ Abstract"
	Project Narrative/Technical Proposal	Attach to Block 8 "Project Narrative"
	Bibliography	Attach to Block 9 "Bibliography"
	Facilities and Other Resources	Attach to Block 10 "Facilities and Other Resources"
	Equipment	Attach to Block 11 "Equipment"
Disclosure of Lobbying Activities (SF-LLL) *(if applicable)*	N/A	N/A
Attachments Form	Attachment 1 – Draft IPP	Upload as Attachment 1
	Attachment 2 – Structure and Management Plan	Upload as Attachment 2
	Attachment 3 – Signed AoC	Upload as Attachment 3
	Attachment 4 – Collaboration and Workforce Development Plan	Upload as Attachment 4
	Attachment 5 – Quad Chart	Upload as Attachment 5

Table 5: Phase II Package Forms and Attachments.

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

- Block 1 – Type of Submission. Applicants should indicate the Phase II submission is an "Application."
- Block 2.1 – Applicant Identifier. Not applicable.

- Block 3 – Date Received by State. Not applicable.
- Block 3.1 – State Application Identifier. Not applicable.
- Block 4b – Agency Routing Identifier. Enter the corresponding Phase I Grant ID. If resubmissions were involved, enter the Grant ID for the last submission.
- Block 5 – Applicant Information. You must provide a Business Office Point of Contact (BPOC) with an e-mail address.
- Block 19 – Authorized Representative. The "signature of AOR" is not an actual signature and is automatically completed upon submission of the electronic application package.

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

Applicants are required to submit a budget justification. The budget justification should be prepared as outlined in the instructions for the Research and Related Budget and uploaded as an attachment to Section K "Budget Justification" of the Research and Related Budget Form. The budget justification does not have a page limit, but should include sufficiently detailed information for meaningful evaluation to include but not limited to the following:

- The basis for the direct labor hours or percentage of effort (e.g., historical hours or estimates);
- The basis for the direct labor rates or salaries. Labor costs should be predicted upon current labor rates or salaries. These rates may be adjusted upward for forecast salary or wage cost-of-living increases that will occur during the agreement period. The cost proposal should separately identify the rationale applied to base salary/wage for cost-of-living adjustments and merit increases. Each must be fully explained;
- The portion of time to be devoted to the proposed research, management activities, divided between academic and non-academic (summer) terms, when applicable;
- The total annual salary charged to the URA;
- Any details that may affect the salary during the project, such as plans for leave and/or remuneration while on leave.
- Amounts or percentages of cost share, expected benefits to the URA as a result, and institutional parameters for providing cost share.

In addition, the budget justification must specifically address subaward costs and type to include the portion of work to be subawarded with a supporting rationale. The budget justification should include a discussion of how the subawardee(s) cost was determined to be fair and reasonable.

RR Subaward Budget Attachment(s) Form: Detailed cost estimates are required for each proposed subaward (e.g., LRAOs and non-permanent subawardees). The cost estimate for the subawards should include sufficiently detailed information for meaningful evaluation, including all those items listed for the LRO, as well as travel for the required meetings. However, it is recognized that some entities may choose to submit their proprietary rate information directly to the Government in lieu of providing such information to the LRO for inclusion in the cost proposal submitted through www.grants.gov. In such a case, a separate submission can be made directly to the Government via email to DTRA-URA-Program@mail.mil.

Research and Related Senior/Key Person Profile Form (Expanded): The Research and Related Senior/Key Person Profile Form (Expanded) should be completed in its entirety for each of the individuals who will be involved in a significant way in the research and management of the Alliance, e.g., the IIRM-URA PM, RALs, PIs, Co-PIs, etc. This includes any known non-permanent subawardee PIs and Co-PIs.

DTRA does not have a preference for the format of the biographical sketch. Biographical sketches shall be limited to three pages for the key leadership personnel, i.e., the IIRM-URA PM and the RALs. DTRA anticipates that for the IIRM-URA PM the submitted information will provide evidence of successful leadership of collaborative research.

Submission of biographical sketches for additional key personnel, e.g., additional PIs and Co-PIs, is required, but they must be limited to two pages per individual. Applicants should take care to only submit biographical sketches for participating individuals and include non-permanent subawardee PIs/Co-PIs.

Credentials, as documented on the biographical sketches, must minimally include a record of seminal publications in the scientific literature with a citation index and a record of successful research in areas relevant to the IIRM-URA. Collectively, the biographical sketches must demonstrate how the aggregate of skills/expertise across the Alliance provides the required breadth and depth to effectively carry out the proposed program of research.

Additionally, a statement of current and pending support must be provided for each of the key personnel. This statement must include the following items and requires disclosure of all grants and contracts through which the IIRM-URA PM, each RAL, each PI, and each Co-PI is currently receiving or may potentially receive financial support:

- A list of all current projects the individual is working on, in addition to any future support the individual has applied to receive, regardless of the source.
- Title and objectives of the other research projects.
- The percentage per year to be devoted to the other projects.
- The total amount of support the individual is receiving in connection to each of the other research projects or will receive if other proposals are awarded.
- Name and address of the agencies and/or other parties supporting the other research projects.
- Period of performance for the other research projects.

RR Personal Data Form: The Government Accountability Office, in its report GAO-16-14, WOMEN IN STEM RESEARCH: Better Data and Information Sharing Could Improve

Oversight of Federal Grant-making and Title IX Compliance, December 3, 2015, recommended that the DoD collect certain demographic and career information to be able to assess the success rates of women who are proposed for key roles in applications in science, technology, engineering, or mathematics disciplines. To enable this assessment, DTRA is including the OPTIONAL form titled, "Research and Related Personal Data" for proposal submissions. The Research and Related Personal Data Form provided as part of the application package for the Phase II submission should be filled out in its entirety for the PM, all PIs, and Co-PIs on the proposal, including non-permanent subawardee PIs and Co-PIs.

Research and Related Other Project Information Form:

- Block 7 – Project Summary/Abstract. The uploaded project summary should be less than five pages and provide a summary of the basic research in the proposal. The abstract absolutely must not contain any proprietary data or markings.
- Block 8 – Project Narrative (Technical Proposal). The uploaded technical proposal must not exceed 40 pages (excluding references).

  The project narrative (technical proposal) should include a discussion of the research strategy to be employed to advance the state-of-the-art in understanding, predicting, and controlling the interaction of ionizing radiation with matter; a detailed description and justification for five-year research goals of the proposed effort; and a detailed technical discussion. The technical discussion should include the background and objectives of the proposed research, the technical approaches to be pursued, the validation techniques and metrics to be used to validate the models and theories developed in this URA, and the parties involved and the level of effort to be employed (demonstrating that researchers are collaborating and substantially and meaningfully engaged in the research efforts). Where the project narrative includes research topics not listed in this BAA, a rationale must be provided. The project narrative should also clearly:

  - Identify specific scientific challenges and research barriers that relate to fundamental understanding of radiation detectors, survivability of DoD systems, and military functionality following a nuclear event and should provide evidence that the proposed technical approaches can address these challenges in a measured approach across the near- and far-term.
  - Explain in substantial detail the specific scientific plans that will be employed, and provide ample evidence that the approaches are likely to substantially advance the underlying science.
  - Highlight the innovations proposed and how they may lead to an understanding of ionizing radiation matter interaction-related phenomena particularly fundamental laws, theories, and validated models.
  - Show how the proposed research is expected to feed, be fed by, or in some other way link with, research being performed elsewhere within the Alliance.
  - Outline which FAs will be addresses in the IPP and the approach to addressing additional FAs in the BPP and options.

  Protection of Human Subjects. DTRA will not allow any human subject use in the IIRM-URA.

Animal Use. DTRA will not allow any animal use in the IIRM-URA.

- Block 9 – Bibliography. Attach a list of the applicable references for the proposal.
- Block 10 – Facilities and Other Resources. The applicant is to include a listing of facilities and other resources available to support the proposal, including a description of the facilities to be used for the research and experiments, a description of who will have access to these facilities, and how these facilities will enhance the research efforts proposed. Where new research facilities are to be created for the purposes of the IIRM-URA, the development and verification plans are to be described.
- Block 11 – Equipment. The applicant is to include a listing of specialized equipment available to support the proposal, including a description of specialized equipment to be used for the research and experiments, a description of who will have access to the specialized equipment, and how the specialized equipment will enhance the research efforts proposed.

Disclosure of Lobbying Activities (SF-LLL) Form: The Disclosure of Lobbying Activities Standard Form-LLL, if applicable, should be completed.

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

Attachment 1 – Draft IPP. The draft IPP does not have a suggested format or a page limit. The Data Management Plan is not required as part of the draft IPP. The draft IPP should include a draft roadmap laying out proposed research covering the base period and any proposed options.

Attachment 2 – Structure and Management Plan. The Structure and Management Plan for the proposal shall not exceed 10 pages. The plan must include a detailed plan for leadership and efficient management of the IIRM-URA and organizational structures. The LRO, the LRAOs, the approach for incorporating non-permanent subawardees, including identification of initial non-permanent subawardees, and key PIs must be clearly identified. The plan must identify metrics for success, how they will be used, and how they will further the goals of the program. Where available, evidence for the success of these strategies is to be described. The plan must describe approaches to adjusting the research plans in response to research insights gained, evolving research needs, advances in the state of the art, and new collaboration opportunities.

Attachment 3 – AoC. Applicants must submit the AoC signed by a duly authorized representative for each proposed permanent member of the Alliance. Any changes with justification should be detailed in a cover letter to the signed AoC.

Attachment 4 – Collaboration and Workforce Development Plan. The Collaboration and Workforce Development Plan for the proposal shall not exceed 10 pages. The plan must include details for how researchers will collaborate within each RA and across the RAs and describe how this collaboration will further the goals of the program. The plan must describe the processes and toolsets to facilitate collaboration and the document/information controls to be employed. The plan must describe the strategy for collaborating with DTRA and propose collaborative opportunities with DTRA personnel. The plan must include examples of how researchers have successfully collaborated previously in similar programs. The plan must address the general activities, student sandbox, staff rotations, electronic resources, etc. detailed in Section 1.5. The plan must include a strategy for identifying, establishing, and exploiting collaborations with

other related research programs. The plan must describe processes for external communication of research outputs.

Attachment 5 – Quad Chart. The quad chart must be presented on one (1) page. The quad chart must not contain any proprietary data or markings. The quad chart must be provided in landscape layout.

4.3. Unique Entity Identifier and System for Award Management

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

Each applicant is required to: (i) Be registered in SAM before submitting its application; (ii) provide a valid unique entity identifier in its application; and (iii) continue to maintain an active SAM registration with current information at all times during which it has an active Federal award or an application or plan under consideration by a Federal awarding agency.

DTRA may not make a Federal award to an applicant until the applicant has complied with all applicable unique entity identifier and SAM requirements and, if an applicant has not fully complied with the requirements by the time DTRA is ready to make a Federal award, DTRA may determine that the applicant is not qualified to receive a Federal award and DTRA may use that determination as a basis for making a Federal award to another applicant.

4.4. Submission Dates and Times

Applicants must submit a Letter of Intent (LoI) no later than 21 June 2019 to be considered eligible to submit a Phase I pre-proposal. Phase I pre-proposal submissions are due on 17 July 2019. The due date for the Phase II invited proposal submissions will be provided in the letter of invitation. The applicant will not be allowed less than 30 days to prepare a full proposal submission; there is no penalty for early submissions.

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

Acceptable evidence to establish the time of receipt and acceptance at www.grants.gov includes documentary and electronic evidence of receipt maintained by DTRA. Applicants should also print, and maintain for their records, the three emails that will serve as the electronic receipt following submission of a Phase I pre-proposals and invited Phase II proposal to www.grants.gov.

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

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

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

If an emergency or unanticipated event interrupts normal Government processes so that proposals cannot be submitted to www.grants.gov by the exact time specified by DTRA correspondence, the time specified for receipt of applications will be deemed to be extended to the same time of day specified in the BAA or in the letter of invitation on the first work day on which normal Government processes resume.

4.5. Intergovernmental Review

Not Applicable.

4.6. Funding Restrictions

Applicants must be advised that DTRA will not allow reimbursement of pre-award costs.

4.7. Other Submission Requirements

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

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

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

4.7.2. Page Definition. Documents must not exceed provided page limits. 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. All documents must be provided in portrait layout unless otherwise noted. In instances where page limits are exceeded, only the pages up to the limit will be reviewed. Exceptions WILL NOT be made under any circumstances.

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

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

4.7.4. Withdrawal of Submissions. Phase I pre-proposals and invited Phase II proposals may be withdrawn by written notice. Withdrawals are effective upon receipt of notice by the

Grants/Contracting Officer via the e-mail address listed in Section 7.

4.7.5. English Language Requirement. All documents must be submitted in the English language. DTRA will not review any documents that are not submitted in the English language. Exceptions WILL NOT be made under any circumstances.

4.7.6. Incomplete Applications and Requests for Additional Information. Pre-proposal and proposal submissions that are not compliant will not be further evaluated. DTRA reserves the right to consider request any additional information via email. Should the applicant fail to respond to email requests from DTRA, at their discretion, DTRA will not consider the proposal further.

4.7.7. Compliance with Appendix A to 32 CFR 28. All awards require certifications of compliance with Appendix A to 32 CFR 28 regarding lobbying. Proposers are certifying compliance with this regulation by submitting the invited proposal. It is not necessary to include the certification text with your invited proposal. If applicable, proposers should submit the Disclosure of Lobbying Activities (SF-LLL) Form in accordance with Section 4.2.3.

4.7.8. Marking Guidance and Disclosure of Proprietary Information other than to the Government. Submissions in response to this BAA may contain technical and other data that the applicant does not want disclosed to the public or used by the Government for any purpose other than application evaluation. Public release of information will be subject to existing statutory and regulatory requirements.

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

> *"For any purpose other than to evaluate this submission, 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 document."*

Any other legend may be unacceptable to the Government and may constitute grounds for removing the submission 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 data on lines specifically identified by asterisk (*) are subject to the restriction on the front page of this document."*

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

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

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

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5. APPLICATION REVIEW INFORMATION

5.1. Evaluation Criteria

5.1.1. Phase I Pre-Proposal Evaluation Criteria. The three evaluation criteria to be used for pre-proposal evaluations are as follows:

1. Scientific Merit and Relevance. Evaluation of this factor will concentrate on the overall scientific and technical merit, relevance to the articulated challenges, and innovation of the proposed research in light of the state-of the-art. Evaluation of this factor will also concentrate on the long term relevance of the proposed research and the likelihood this proposed research will address scientific challenges and research barriers facing DTRA.
2. Collaboration and Program Management. Evaluation of this factor will concentrate on the applicant's strategies, plans and experience in fostering collaborative research, managing collaborative research programs, and workforce development. Evaluation of this factor will be based on evidence of previous successful relevant efforts and the applicant's commitment and plans for collaboration and workforce development. Evaluation of this factor will focus on the PM's technical leadership and experience in managing large collaborative research programs and the applicant's plans to meet the requirements of the overall management concept. The extent to which applicants address the Student Pipeline Development will be considered. The extent to which applicants identify and commit to inclusion of junior faculty and junior staff researchers and their professional growth as part of the Alliance will be considered. The extent to which applicants identify and commit to representation of HBCUs/MIs in the Alliance will also be considered. This factor includes plans for an environment to foster collaboration and efforts to bring about a unity of vision for the consortium and drive for results and benefits.
3. Experience and Qualifications of Scientific Staff. Evaluation of this factor will concentrate on the relevant qualifications, capabilities, availability, accomplishments, and

experience of the applicant's proposed research personnel as an indication of their ability to achieve the proposed technical objectives.

5.1.2. Phase II Invited Proposal Evaluation Criteria. The five evaluation criteria to be used for Phase II invited proposal evaluations are as follows:

1. Scientific Merit and Relevance. Evaluation of this factor will concentrate on the overall scientific and technical merit, relevance to the articulated challenges, and innovation of the proposed research in light of the state-of the-art. Evaluation of this factor will also concentrate on the long term relevance of the proposed research and the likelihood this proposed research will address scientific challenges and research barriers facing DTRA.
2. Collaboration and Workforce Development. Evaluation of this factor will concentrate on the applicant's strategies, plans and experience in fostering collaborative research, managing collaborative research programs, and workforce development. Evaluation of this factor will be based on evidence of previous successful relevant efforts and the applicant's commitment and plans for collaboration and workforce development. This factor includes plans for an environment to foster collaboration and develop the workforce. The extent to which applicants address the Student Pipeline Development will be considered. The extent to which applicants identify and commit to inclusion of junior faculty and junior staff researchers and their professional growth as part of the Alliance will be considered. The extent to which applicants identify and commit to representation of HBCUs/MIs in the Alliance will also be considered. This factor includes efforts to bring about a unity of vision for the consortium and drive for results and benefits.
3. Experience and Qualifications of Scientific Staff and Quality of Research Facilities. Evaluation of this factor will concentrate on the relevant qualifications, capabilities, availability, accomplishments, and experience of the applicant's proposed research personnel as an indication of their ability to achieve the proposed technical objectives related to the proposed efforts. Key personnel are expected to be substantially and meaningfully engaged in the research and the proposed level of effort for key personnel should be commensurate with and demonstrate such. The extent to which the applicant's proposed facilities and equipment will contribute to the accomplishment of the proposed research will be evaluated including the nature, quality, relevance, availability, and access to state-of-the art research facilities and equipment.
4. Program Management. Evaluation of this factor will include the adequacy of the overall management plan, internal team structures, and composition with respect to achieving the research goals of the program. These approaches should be lightweight and will be evaluated for their flexibility to minimize overhead, yet ensure research relevance and proper oversight. Where available, evidence for the success of these strategies is to be described. Evaluation of this factor will include a focus on the Program Manager's technical leadership and experience in managing large collaborative research programs and the applicant's plans to meet the requirements of the overall management concept included in the BAA. This factor includes the proposed plan for incorporating and managing non-permanent subawardees.
5. Cost Realism. Evaluation of this area will consider cost realism, cost reasonableness, and affordability within funding constraints. The Government may make adjustments to the

cost of the total proposed effort as deemed necessary to reflect what the effort should cost. These adjustments will consider the task undertaken and approach proposed. These adjustments may include upward or downward adjustments to proposed labor hours, labor rates, quantity of materials, price of materials, overhead rates, general and administrative expenses (G&A), etc. The result of the realism evaluation will be a determination of the most probable cost to the Government of performance. The most probable cost may differ from the proposed cost. The most probable cost, rather than the proposed cost, shall be used in the trade-off process to determine selection for funding.

5.2. Review and Selection Process

The Phase I pre-proposal and invited Phase II proposal selection process will be conducted based upon a technical review as described in the DoDGARs (32 CFR 22.315(c)) and may include the use of non-Government peer-reviewers. Phase I pre-proposals and Phase II proposals may be evaluated by a group of qualified scientists and managers from the Government as well as subject matter experts from outside the Government. In all instances when non-Government evaluators will be used, they will be required to sign a non-disclosure agreement and conflict of interest (COI) statement before being provided access to Phase I pre-proposals and invited Phase II proposals. Additional information is included in Section 8.1.

The Phase I pre-proposal evaluation will be based on three criteria listed in decreasing order of importance: 1) Scientific Merit and Relevance, 2) Collaboration and Program Management, and 3) Experience and Qualifications of Scientific Staff. The criteria will be scored as Outstanding (O), Good (G), Acceptable (A), Marginal (M) or Unacceptable (U). Phase I pre-proposals scored as "Unacceptable" in any single category will be deemed "Not Selectable" and will not be considered further.

The invited Phase II proposal evaluation will be based on five criteria; however, only criteria one to four are weighted. They are listed in decreasing order of importance: 1) Scientific Merit and Relevance, 2) Collaboration and Workforce Development, and 3) Experience and Qualifications of Scientific Staff and Quality of Research Facilities, and 4) Program Management. These criteria will be scored as Outstanding (O), Good (G), Acceptable (A), Marginal (M) or Unacceptable (U). The fifth criterion of Cost Realism will be scored as Acceptable (A) or Unacceptable (U). Invited Phase II proposal scored as "Unacceptable" in any single category will be deemed "Not Selectable" and will not be considered further.

Only the most highly rated Phase I pre-proposals will receive an invitation to submit a Phase II proposal. Applicants that do NOT receive an invitation from the Government to submit a Phase II proposal are NOT eligible to submit a Phase II proposal. Applicants not receiving an invitation to submit Phase II proposals will be informed of such via email following the Phase I pre-proposal evaluations.

Prior to award, the Government reserves the right to perform a review of past performance. Sources that may be used for past performance review may include the Past Performance Information Retrieval System (PPIRS) and the Federal Awardee Performance and Integrity Information System (FAPIIS). The Government will also evaluate the impact of any proposed limitations to the use of intellectual property (e.g. asserted technical data/computer software restrictions or patents) during the selection and/or negotiation process, and may request additional information from the applicant, as may be necessary, to evaluate the applicant's assertions.

The potential relationship of the proposed research and development to the DTRA mission will be considered during the selection process. Other factors that may be considered include duplication with other research, program balance, 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.

The Government will not review any submission that is not relevant to this BAA or Phase II proposals that were not invited. The Government reserves the right to select all, some, or none of the proposals, or any part of any proposal received in response to this BAA and to make awards without discussions with applicants; however, the Government reserves the right to conduct discussions if determined necessary.

5.3. Simplified Acquisition Threshold

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

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

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

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

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

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6. AWARD ADMINISTRATION INFORMATION

6.1. Award Notices

Applicants will be notified regarding the status of their applications via e-mail to the BPOC listed in Block 5 of the SF-424 and the PI listed in Block 14 of the SF-424 provided at the time of submission.

A 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 CA document to the selected applicant. Also, this notification must not be used as a

basis for accruing costs to the Government prior to award. Selected applicants are not authorized to begin work, as any award is subject to successful negotiations (if determined necessary by DTRA) between the DTRA contracting division and the selected organization, and to the availability of funds.

All notifications will be made from DTRA-URA-Program@mail.mil.

Applicants must be aware that it is their responsibility to ensure: (1) correct e-mail addresses are provided at the time of submission, (2) this e-mail notification reaches the intended recipient(s), and (3) the e-mail is not blocked by the use of 'spam blocker' software or other means that the recipient's Internet Service Provider may have implemented as a means to block the receipt of certain e-mail messages.

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

6.2. Administrative and National Policy Requirements

Awards from this BAA will be governed by the DoD Research and Development General Terms and Conditions, the most current version as of the date of the award (available for download at website http://www.onr.navy.mil/Contracts-Grants/submit-proposal/grants-proposal/grants-terms-conditions.aspx). DTRA-specific Terms and Conditions governing intellectual property, required reporting, payment information, etc. will be provided at the time of award negotiations. All awards require certifications of compliance with national policy requirements. Statutes and Government-wide regulations require some certifications to be submitted at the time of proposal submission.

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

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

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

6.2.3. Reporting Subawards and Executive Compensation. The recipient agrees to ensure they have the necessary processes and systems in place to comply with the reporting requirements of

the Transparency Act, as defined at 2 CFR 170.320, unless they meet the exception under 2 CFR 170.110(b).

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

6.3. Reporting

General requirements are provided below; however, each awardee should check the award agreement and/or terms and conditions to determine the requirements for that specific award.

6.3.1. Quarterly Technical Reports. Quarterly roll up of technical accomplishments/data, including a listing of patents, publications, and presentations. The quarterly report should also include a listing of projects that have started/ended, financial metrics (e.g., expenditures by institution), and a staffing update of current efforts under the award. The quarterly report should also include any scientific or programmatic impediments that need to be addressed by the partnership.

6.3.2. Annual Reports. Annual Reports are due annually on the anniversary of the award. The Annual Report is *not* a cumulative report.

6.3.3. Final Technical Reports. A comprehensive final technical report is required prior to the end of an effort, due on the date specified in the terms and conditions of the award document. The purpose of the Final Report is to document the results of the effort. The Final Report *is* a cumulative report. The final report will be sent to the Defense Technical Information Center (DTIC) and reports may be available to the public through the National Technical Information Service (NTIS).

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

7. AGENCY CONTACTS

Questions regarding the content of this BAA must be addressed to the following email address: DTRA-URA-Program@mail.mil.

DTRA will not release employee personal contact information.

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8. OTHER INFORMATION

8.1. Technical and Administrative Support by Non-Government Personnel

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

Further, participation in this BAA requires DTRA support contractors to have access to Phase I pre-proposal and invited Phase II proposal information including information that may be considered proprietary or otherwise marked with restrictive legends. Existing DTRA contractors include but may not be limited to the following: Cherokee Nation Strategic Programs, LLC (contract specialist support); Kent, Campa and Kate, Inc. (contract closeout support); SAIC (advisory and assistance services); Quanterion Solutions, Inc. (DTRIAC); Kforce Government Solutions, Inc. (financial/accounting support); and CACI (contract writing system administration). Each contract contains organizational conflict of interest provisions and/or includes contractual requirements for non-disclosure of proprietary contractor information or data/software marked with restrictive legends. The applicant, by submitting a Phase I pre-proposal and invited Phase II proposal, is deemed to have consented to the disclosure of its information to the aforementioned contractors under the conditions and limitations described herein.

All individuals—including subject matter experts and support contractors—having access to any proposal information shall execute nondisclosure agreements certifying that they do not have conflicts of interest and that they will not disclose any information pertaining to this BAA including any submittal, the identity of any submitters, or any other information relevant to this BAA. All applicants to this BAA consent to the disclosure of their information under these conditions.