Defense Threat Reduction Agency
SBIR 22.4 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

1.0 INTRODUCTION

The Defense Threat Reduction Agency (DTRA) mission is to enable the DoD, the U.S. Government, and International Partners to counter and deter Weapons of Mass Destruction (WMD) Chemical Biological, Radiological, Nuclear) and Improvised Threat Networks. The DTRA SBIR program is consistent with the purpose of the Federal SBIR/STTR Program, i.e., to stimulate a partnership of ideas and technologies between innovative small business concerns and through Federal-funded research or research and development (R/R&D).

The approved FY22.4 topics solicited for the Defense Threat Reduction Agency (DTRA) Small Business Innovation Research (SBIR) Program are included in these instructions followed by the full topic description. Offerors responding to this Broad Agency Announcement (BAA) must follow all general instructions provided in the related Department of Defense Program BAA and submit proposals by the date and time listed in the DoD Annual Program BAA. Specific DTRA requirements that add to or deviate from the DoD Annual Program BAA instructions are provided below with references to the appropriate section of the DoD document.

The DTRA Small Business Innovation Research (SBIR) Program is implemented, administered, and managed by the DTRA SBIR/STTR Program Office. Specific questions pertaining to the administration of the DTRA SBIR Program and these proposal preparation instructions should be submitted to:

Mr. Mark D. Flohr
DTRA SBIR/STTR Program Manager
Mark.D.Flohr.civ@mail.mil
Tel: (571) 616-6066

Defense Threat Reduction Agency
8725 John J. Kingman Road
Stop 6201
Ft. Belvoir, VA 22060-6201

For technical questions about specific topic requirements during the pre-release period, contact the DTRA Technical Point of Contact (TPOC) for that specific topic. To obtain answers to technical questions during the formal BAA open period, visit: https://www.dodsbirsttr.mil. For questions regarding the Defense SBIR/STTR Innovation Portal, contact DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com.

Proposals not conforming to the terms of this announcement will not be considered. DTRA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by DTRA will be funded. DTRA reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues).

Please read the entire DoD announcement and DTRA instructions carefully prior to submitting your proposal as there have been significant updates to the requirements.

The SBIR/STTR Policy Directive is available at: SBIR and STTR Policy Directive - October 2020

2.0 SMALL BUSINESS ELIGIBILITY REQUIREMENTS

2.1 The Offeror

Each offeror must qualify as a small business at time of award per the Small Business Administration (SBA) regulations at 13 CFR 121.701-121.705 and certify to this in the Cover Sheet section of the proposal. Those small businesses selected for award will also be required to submit a Funding Agreement Certification document provided by DTRA contracts prior to award.

2.2 SBA Company Registry

Per the 2020 SBIR-STTR Policy Directive, all SBIR offerors are required to register their firm at SBA's Company Registry prior to submitting a proposal. Upon registering, each firm will receive a unique control ID to be used for submissions at any of the eleven (11) participating agencies in the program. For more information, please visit the SBA's Firm Registration Page: https://www.sbir.gov/user/login/.

2.3 Use of Foreign Nationals, Green Card Holders and Dual Citizens

See the "Foreign Nationals" section of the DoD SBIR Broad Agency Announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals, green-card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Offers must identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For those individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted to export control-restricted topics and/or those with foreign nationals, dual citizens or green card holders listed will be subject to security review during the contract negotiation process (if selected for award). DTRA reserves the right to vet all uncleared individuals involved in the project, regardless of citizenship, who will have access to Controlled Unclassified Information (CUI) such as export-controlled information. If the security review disqualifies a person from participating in the proposed work, the contractor may propose a suitable replacement. In the event a proposed person is found ineligible by the government to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale. In the event a firm is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale.

3.0 PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Annual Program BAA.

3.1 Technical Volume (Volume 2)

The Phase I technical volume is not to exceed 20 pages in length and must follow the formatting requirements provided in the DoD SBIR Annual Program BAA. Any pages in the technical volume over the 20 pages will not be considered in the proposal evaluations.

3.2 Content of the Technical Volume

The Technical Volume should cover the following items <u>in the order given below</u>:

(a) Identification and Significance of the Problem or Opportunity.
Define the specific technical problem or opportunity addressed and its importance.

(b) Phase I Technical Objectives.
Enumerate the specific objectives of the Phase I work, including the questions the research and development effort will try to answer to determine the feasibility of the proposed approach.

(c) Phase I Statement of Work (including Subcontractors' Efforts)

(1) Provide an explicit, detailed description of the Phase I approach. The Statement of Work should indicate what tasks are planned, how and where the work will be conducted, a schedule of major events, and the final product(s) to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the Technical Volume section.

(2) This BAA may contain topics that have been identified by the Program Manager as research or activities involving Human/Animal Subjects and/or Recombinant DNA. In the event that Phase I performance includes performance of these kinds of research or activities, please identify the applicable protocols and how those protocols will be followed during Phase I. Please note that funds cannot be released or used on any portion of the project involving human/animal subjects or recombinant DNA research or activities until all of the proper approvals have been obtained as indicated in the DoD BAA. **Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.**

(d) Related Work.
Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The technical volume must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic. Describe previous work not directly related to the proposed effort but similar. Provide the following:

(1) Short description,
(2) Client for which work was performed (including individual to be contacted and phone number), and
(3) Date of completion.

(e) Relationship with Future Research or Research and Development

(1) State the anticipated results of the proposed approach if the project is successful.

(2) Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

(3) Identify the applicable clearances, certifications and approvals required to conduct Phase II testing and outline the plan for ensuring timely completion of said authorizations in support of Phase II research or research and development effort.

(f) Commercialization Strategy. Describe in approximately one page your company's strategy for commercializing this technology in DoD (such as a formal DoD Program), other Federal Agencies, and/or private sector markets. Provide specific information on the market need the technology will address and the size of the market. Also include a schedule showing the quantitative commercialization results from this SBIR project that your company expects to achieve.

(g) Key Personnel. Identify key personnel who will be involved in the Phase I effort including information on directly related education and experience. A concise technical resume of the principal investigator, including a list of relevant publications (if any), must be included (Please do not include Privacy Act Information). All resumes will count toward the page limitations for Volume 2.

(h) Foreign Citizens. Identify any foreign citizens or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. Proposers frequently assume that individuals with dual citizenship or a work permit will be permitted to work on an SBIR project and do not report them. This is not necessarily the case and a proposal will be rejected if the requested information is not provided. Therefore, firms should report any and all individuals expected to be involved on this project that are considered a foreign national as defined in the BAA. You may be asked to provide additional information (e.g., copy of valid passport, visa, work permit, etc.) during negotiations in order to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

(i) Facilities/Equipment. Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Justify equipment purchases in this section and include detailed pricing information in the Cost Volume. State whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name), and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

(j) Subcontractors/Consultants. Involvement of a university or other subcontractors or consultants in the project may be appropriate. If such involvement is intended, it should be identified and described to the same level of detail as the prime contractor costs. A minimum of two-thirds of the research and/or analytical work in Phase I, as measured by direct and indirect costs, must be conducted by the proposing firm, unless otherwise approved in writing by the Contracting Officer. SBIR efforts may include subcontracts with Federal Laboratories and Federally Funded Research and Development Centers (FFRDCs). A waiver is no longer required for the use of federal laboratories and FFRDCs; however, proposer must certify their use of such facilities on the Cover Sheet of the proposal.

(k) Prior, Current, or Pending Support of Similar Proposals or Awards. If a proposal submitted in response to this BAA is substantially the same as another proposal that was funded, is now being funded, or is pending with another Federal Agency, or another or the same DoD Component, you must reveal this on the Proposal Cover Sheet and provide the following information. Refer to the instructions provided in the DoD STTR BAA for this requirement.
Note: If this does not apply, state in the proposal "No prior, current, or pending support for Proposed work"

3.3 Cost Volume (Volume 3)

The Phase I Base amount must not exceed $167,500.00. DTRA provides a MSExcel workbook for the Cost Volume as template for proposal use. The Cost Volume template is available in the DSIP portal.

Important: when completing the cost volume, enough information should be provided to allow the agency to understand how you plan to use the requested funds if a contract is awarded. Itemized costs of any subcontract or consultant should be provided to the same level as for the prime small business. If an unsanitized version of costs cannot be provided with the proposal, the Government may request it during negotations if selected. Refer to the instruction provided in the DoD SBIR program BAA for additional details on the content of the Cost Volume.

Note: Cost for travel funds must be justified and related to the needs of the project. DTRA does not include any fee on travel costs, so proposal should exclude fee on any travel costs proposed.

For more information about cost proposals and accounting standards, see https://www.dcaa.mil/Guidance/Audit- Process-Overview/.

3.4 Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Annual Program BAA for full details on this requirement. Information contained in the CCR will not be considered by DTRA during proposal evaluations.

3.5 Supporting Documents (Volume 5)

Volume 5 is provided for proposers to submit additional documentation to support the Coversheet (Volume 1), Technical Volume (Volume 2), and the Cost Volume (Volume 3).

(a) All proposers are REQUIRED to submit the following documents to Volume 5:
   1. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (BAA

Attachment 1) (REQUIRED)

2. Foreign Ownership or Control Disclosure (BAA Attachment 2) (Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability)

(b) Any of the following documents may be included in Volume 5 if applicable to the proposal.

1. Letters of Support
2. Additional Cost Information
3. Funding Agreement Certification
4. Technical Data Rights (Assertions)
5. Lifecycle Certification
6. Allocation of Rights

4.0 DIRECT TO PHASE II PROPOSAL GUIDELINES

The Defense Threat Reduction Agency does not participate in the Direct to Phase II Program.

5.0 PHASE II PROPOSAL GUIDELINES

Small business concerns awarded a Phase I contract are permitted to submit a Phase II proposal for evaluation and potential award selection. The Phase II proposals are best submitted no later than (NLT) 30 days AFTER the end of the 7 month Phase I period of performance.

All SBIR Phase II awards made on topics from solicitations prior to FY13 will be conducted in accordance with the procedures specified in those solicitations.

DTRA is not responsible for any money expended by the proposer prior to contract award.

DTRA has established a **40-page limitation** for the Technical Volume submitted in response to its topics. This does not include the Proposal Cover Sheets (pages 1 and 2, added electronically by the DoD submission site), or the Cost Volume, or the Company Commercialization Report. The Technical Volume includes, but is not limited to: table of contents, pages left blank, references and letters of support, appendices, key personnel biographical information, and all attachments.

Further details on the due date, content, and submission requirements of the Phase II proposal will be provided either in the Phase I award or by subsequent notification.

Phase II Proposal Instructions

Each Phase II proposal must be submitted through the Defense SBIR/STTR Innovation Portal by the deadline as specified in the Phase II Proposal Guidelines, or in the Phase I award or subsequent notification. **The format should be similar to Phase I proposal except the Phase II Technical Proposal is limited to 40 pages.** Each proposal submission must contain a Proposal Cover Sheet, Technical Volume, Cost Volume, a Company Commercialization Report (see the appropriate section of the BAA Announcement) and Volume 5. The Commercialization Strategy Volume should be more specific than was required for Phase I.

As indicated in the DoD STTR Annual Program BAA, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool.

Commercialization Strategy

See the appropriate section DoD SBIR 22.4 BAA.

Phase II Evaluation Criteria

Phase II proposals will be reviewed for overall merit based upon the criteria specified in this Broad Agency Announcement and will be similar to the Phase I process.

Public Release of Award Information

If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released via the Internet. Therefore, do not include proprietary or classified information in these sections. For examples of past publicly released DoD SBIR/STTR Phase I and II awards, visit https://www.dodsbirsttr.mil/submissions/login.

6.0 DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

In accordance with the Small Business Act (15 U.S.C. 632), DTRA will authorize the recipient of a Phase I or Phase II SBIR/STTR award to purchase Discretionary Technical & Business Assistance services, such as access to a network of scientists and engineers engaged in a wide range of technologies, or access to technical and business literature available through on-line data bases, for the purpose of assisting such concerns as:

- making better technical decisions concerning such projects;
- solving technical problems which arise during the conduct of such projects;
- minimizing technical risks associated with such projects;
- developing/ commercializing new commercial products/processes resulting from such projects; and,
- meeting cyber security requirements.

If you are proposing use of Discretionary Technical and Business Assistance (TABA), you must provide a cost breakdown in the Cost Volume under "Other Direct Costs (ODCs)" and provide a one-page description of the vendor you will use and the Technical and Business Assistance you will receive. For the Phase I project, the amount for TABA may not exceed $6,500 per award. For the Phase II project, the TABA amount may be less than, equal to, but not more than $50,000 per project. The description should be included in Volume 5 of the proposal.

Approval of Discretionary Technical and Business Assistance is not guaranteed and is subject to review of the contracting officer.

For Discretionary Technical and Business Assistance, small business concerns may propose one or more vendors. Additionally, business-related services aimed at improving the commercialization success of a small business concern may be obtained from an entity, such as a public or private organization or an agency or other entity established or funded by a State that facilitates or accelerates the commercialization of technologies or assists in the creation and growth of private enterprises that are commercializing technology.

7.0 EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA.

7.1 DTRA Evaluation Authority. DTRA has a single Evaluation Authority (EA) for all proposals received under this solicitation. The EA either selects or rejects Phase I and Phase II proposals based upon the results of the review and evaluation process plus other considerations including limitation of funds, and investment balance across all the DTRA topics in the solicitation. To provide this balance, a lower rated proposal in one topic could be selected over a higher rated proposal in a different topic. DTRA reserves the right to select all, some, or none of the proposals in a particular topic.

7.2 Notifications. Following the EA decision, the DTRA SBIR/STTR office will release notification e-mails of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. E-mails will be sent to the addresses provided for the Principal Investigator and Corporate Official. Offerors may request a debriefing of the evaluation of their not selected proposal and should submit this request via email to: dtra.belvoir.RD.mbx.sbir@mail.mil and include "SBIR 22.4 / Topic XX Debriefing Request" in the subject line. Debriefings are provided to help improve the offeror's potential response to future solicitations. Debriefings do not represent an opportunity to revise or rebut the EA decision.

For selected offers, DTRA will initiate contracting actions which, if successfully completed, will result in contract award. DTRA Phase I awards are issued as fixed-price purchase orders with a maximum period of performance of seven-months. DTRA may complete Phase I awards without additional negotiations by the contracting officer or without opportunity for revision for proposals that are reasonable and complete.

7.3 DTRA Support Contractors

Select DTRA-employed support contractors may have access to contractor information, technical data or computer software that may be marked as proprietary or otherwise marked with restrictive legends. Each DTRA support contractor performs under a contract that contains organizational conflict of interest provisions and/or includes contractual requirements for nondisclosure of proprietary contractor information or data/software marked with restrictive legends. These contractors require access while providing DTRA such support as advisory and assistance services, contract specialist support, and support of the Defense Threat Reduction Information Analysis Center (DTRIAC). The contractor, by submitting a proposal or entering into this contract, is deemed to have consented to the disclosure of its information to DTRA's support contractors.

The following are, at present, the prime contractors anticipated to access such documentation: Broadleaf Inc (contract specialist support), Kent, Campa and Kate, Inc. (contract closeout support), ARServices (Program Management Advisory and Assistance Services--A&AS), Systems Planning and Analysis, Inc. (Subject Matter Expertise A&AS), Polaris Consulting (Small Business Program Support), Seventh Sense Consulting, LLC (Acquisition Support), Kapili Services, LLC and TekSynap (DTRIAC) and Savantage Solutions (Accounting and Financial Systems Support). This list is not all inclusive (e.g., subcontractors) and is subject to change.

7.4 Protests. Refer to the DoD SBIR Annual Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Service of Protest (Sept 2006)

(a) Protests, as defined in section 33.101 of the Federal Acquisition Regulation, that are filed directly with an agency, and copies of any protests that are filed with the Government Accountability Office (GAO), shall be served on the Contracting Officer (addressed to Mr. Herbert Thompson, Contracting Officer, as follows) by obtaining written and dated acknowledgment of receipt from (if mailed letter) Defense Threat Reduction Agency, ATTN: AL-ACQ (Mr. Herbert Thompson), 1680 Texas Street, Kirtland AFB, NM 87117. If Federal Express is used for the transmittal, the appropriate address is: Defense Threat Reduction Agency, ATTN: AL-ACQ (Mr. Herbert Thompson), 8151 Griffin Avenue SE, Building 20414, Kirtland AFB, NM 87117-5669.

(b) The copy of any protest shall be received in the office designated above within one day of filing a protest with the GAO.

(End of provision)

8.0 AWARD AND CONTRACT INFORMATION

DTRA plans on Phase I projects for a seven (7) month period of performance with six months devoted to the research and the final month for the final report. The award size of the Phase I contract is no more than $167,500.00 not withstanding a maximum of $6,500.00 for Discretionary Technical and Business Allowance (TABA). For a Phase II project, DTRA plans on a 24 month period of performance. The award size of a Phase II contract is no more than $1,100,000.00 not withstanding a maximum of $50,000.00 for Discetionary Technical and Business Allowance (TABA).

9.0 ADDITIONAL INFORMATION

9.1 Export Control Restrictions

The International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, will apply to all projects with military or dual-use applications that develop beyond fundamental research, which is basic and applied research ordinarily published and shared broadly within the scientific community. More information is available at https://www.pmddtc.state.gov/ddtc_public.

The technology within some DTRA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export-controlled items based on user, country, and purpose. **The offeror must ensure that their firm complies with all applicable export control regulations.**

NOTE: Export control compliance statements found in these proposal instructions are not meant to be all inclusive. They do not remove any liability from the submitter to comply with applicable ITAR or EAR export control restrictions or from informing the Government of any potential export restriction as fundamental research and development efforts proceed.

9.2 Cyber Security

Any Small Business Concern receiving an SBIR award is required to provide adequate security on all covered contractor information systems. Specific security requirements are listed in DFARS 252.204.7012, and compliance is mandatory.

9.3 Feedback

In an effort to encourage participation in, and improve the overall SBIR award process, offerors may submit feedback on the SBIR solicitation and award process to: dtra.belvoir.RD.mbx.sbir@mail.mil for consideration for future SBIR BAAs.

DTRA SBIR 22.4 Topic Index
Release 1

DTRA224-001	Identification and quantification of single atoms in low S/N images using Machine Learning and Neural Networks towards near-real-time isotope identification using Atom Trap Trace Analysis
DTRA224-002	Predictive Algorithms to Develop Payload-Agnostic Carriers for Crossing the Blood-Brain Barrier
DTRA224-003	Non-Traditional Radiation Hardness Evaluation Tools for Complex Highly Integrated Microelectronic Components
DTRA224-004	Novel Signature Collection Methods for Distributed Sensors
DTRA224-005	Optically-based Standoff Diagnostic to Interrogate the Evolution of Liquid Ejected from Containers Impacted by Shock and Fragments

DTRA224-001 TITLE: Identification and quantification of single atoms in low S/N images using Machine Learning and Neural Networks towards near-real-time isotope identification using Atom Trap Trace Analysis

OUSD (R&E) MODERNIZATION PRIORITY: Nuclear; Artificial Intelligence/ Machine Learning

TECHNOLOGY AREA(S): Nuclear; Battlespace

OBJECTIVE: To investigate and develop an artificial intelligence / machine learning based method to quickly, efficiently, and accurately identify and quantify atoms in low Signal to Noise (S/N) images produced by Atom Trap Trace Analysis (ATTA) systems. The focus of the Machine Learning research will be to develop and demonstrate the continuous operation of systems as used in ATTA numerical analysis approaches with quick and accurate results over a broad range of (radio) activities / isotope concentrations. With current working count range of 50-5000 trace atoms/hr, the AI/ML method should seek to seamlessly extend significant capability beyond that range with emphasis on the lower end range. The researcher will demonstrate that this method has significant value by outperforming current methods in both metrics of speed and accuracy. The successful research will detect images of atoms and quantify atom number, as well as non-integer atom numbers and spurious event classifications, plus quantify the performance in these metrics, specifically in low-level to very-low detection applications. The researcher will demonstrate the viability of integration of Machine Learning / Neural Net data processing into current ATTA systems for continuous ATTA operation and improved turnaround time, with a goal towards a Near-Real-Time monitoring capability of rare gas radionuclides in support of improved information for nuclear monitoring decision makers.

DESCRIPTION: The concept of using noble gas radioisotope detection to infer information about nuclear activity has been used by monitoring communities for a number of years [1-3]. Most commonly, detection stations are SAUNA systems (Scienta Sauna Systems, Sweden), or similar, and are based on so called Beta-Gamma (β – γ) coincidence counting. Another technology that can detect and quantify the various Xe isotopes is high resolution mass spectroscopy (HRMS)[4]. An additional new technology for rare gas isotope analysis is the Atom Trap Trace Analysis (ATTA) system, offering valuable additional capability to existing methods. This laser-based method uses lasers to trap and confine specific rare gas isotopes into a small spatial region where the fluorescence from these trapped atoms is imaged onto a CCD camera for detection [5-7] demonstrating very high isotope selectivity and single atom detection capability. The ATTA's capabilities make a strong candidate for precision isotopic analysis in critical field applications as well as extremely accurate monitoring in industrial and government production facilities. The use of the imaging processes in the analysis lends this emerging technology method quite suitable for the development of AI / ML determination applications.

Currently, the images from ATTA are run through a traditional computational algorithm, selecting a Region of Interest (ROI) for pixels where the atoms' fluorescence signal would likely occur and then the count in that region are integrated - to determine the atom number present. For modest abundance samples where 10's to 1000's of atoms may be trapped, this technique has served its purpose very well. Typically, a query for a specific isotope may produce thousands of images to be analyzed in this fashion. For low abundance isotope detection, the foremost limitation on sample analysis turnaround time resides in the time required to obtain a statistically significant count of the few atoms present. In extreme low abundance detection, these images are currently analyzed by hand to determine activity level. In this regime, noise in the images from scattered light or detector noise, partial or non-integer atoms from atoms that are present for only a fraction of the CCD exposure time, and spurious camera

events such as x-rays, cosmic rays, muons etc., can become very significant and can easily lead to large statistical uncertainties in the results or prolonged analysis turnaround times. These counting statistics should be solvable in near real time through and with ML/AI research and development.
At the opposite situation, in the high detection limit when atomic concentrations, and count rates, are higher and high statistics can be achieved relatively quickly, the resolution to determine the exact number of atoms in an image by pure numerical integration of the signal in the ROI (the "atomic peak resolution" for short) can be lost. This issue, in turn, requires changes in procedure and analysis methodology. These changes can introduce other systematics which are of concern when performing a high precision analysis. These counting statistics too should be solvable in near real time through and with ML/AI research and development.

In order to improve the counting statistics and turnaround time of the ATTA systems for radionuclide identification and quantification, advanced and innovative methods for ATTA image analysis and classification using Artificial Intelligence (AI) and Machine Learning (ML) are sought[8]. With the nature and number of the images to be analyzed, advances in Machine Learning make it a promising technology for improving ATTAs image analysis and extending its capabilities. This research would be applicable to other measuring and detection counting applications in the scientific community.

The developed technique should be able to accurately identify and quantify atoms present in an image, accurately flag and manage spurious events, and report a level of statistical certainty, and do so at a performance level significantly greater than the current, traditional approach and do so over an atom detection rate range of 50 – 5000 atoms / hr. The neural network will need to eventually be able to be integrated into the ATTA data acquisition process to guide and inform when counting is statistically acceptable. Ideally, the neural network will also be flexible enough to be used in other, similar applications where ROI determination and quantification in low S/N datasets is needed. A large quantity of datasets of images for ML, representative of ATTA data, and which can be used to train the neural network, will be made available to the awardee. For evaluation of performance metrics and robustness, the given datasets as well as other dataset will be used to compare performance of the neural network against the current algorithm.

Current research in this field has already demonstrated ML approaches to similar applications of atom imaging, counting, and identification; established techniques that may optionally be leveraged in the effort to reach the stated objectives of this research, showing feasibility and interest across fields of study and application [9-11].

PHASE I: To investigate and develop an artificial intelligence / machine learning based method or neural network to quickly, efficiently, and accurately identify and quantify atoms in low S/N images produced by Atom Trap Trace Analysis (ATTA) systems. Using a representative dataset, supplied to the awardee, demonstrate that this AI based method can meet or exceed performance metrics in speed and accuracy of current methods over the full range of atom detection rates. For Phase I, the focus will be on demonstrating the neural network's capability to determine if an atom is present and if so, how many, and will not focus on classification of spurious events or partial/ fleeting atoms in the image. Lay forth a research plan for improving these metrics and expanding capability to meet Phase II metrics. Identify pathways for meeting the Phase II performance goals through feasibility studies at the end of Phase I.

PHASE II: Exhibit advanced capability and performance of the developed AI based method over a broad range of activities / concentrations by demonstrating that the software can also detect and quantify non-integer atoms (aka fleeting atoms that are only present for a fraction of the camera exposure time) as well as flag and classify spurious camera events (such as cosmic rays) that do not accurately contribute to the atom count. Demonstrate that in the extreme low-limit detection, cases where images are currently hand analyzed and count rates are ~1-10 atoms / hr, that the automated AI/ML method can accurately and quickly provide the analysis. The method must also be demonstrated to perform accurately and efficiently over, and preferably beyond, the full working range of 50-5000 atoms / hr and should also address the loss in atomic peak resolution. The method will be evaluated on datasets other than ones used in training the neural network. All performance metrics and statistics must be defined, quantified and presented to directly compare to the current, traditional method. Finally, working with agencies with the ATTA systems, demonstrate integration of this method into those ATTA systems for improved turnaround time of sample analysis towards Near-Real-Time monitoring of rare gas radionuclides, as to augment and add capability to DOD's worldwide effort in rapid radionuclide identification and quantification.

PHASE III DUAL USE APPLICATIONS: Further development to improve neural network performance and adaptability to diverse platforms. Beyond atom counting and classification of spurious events, the images from ATTA also can be analyzed to assess the health of the laser and vacuum systems. Explore using the developed AI/ML method to also monitor / assess system health. Identify additional areas that would benefit from the developed technology and develop plans for dissemination and implementation.

REFERENCES:

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KEYWORDS: machine learning; image analysis and classification; radio-isotope identification; RIID

DTRA224-002 TITLE: Predictive Algorithms to Develop Payload-Agnostic Carriers for Crossing the Blood-Brain Barrier

OUSD (R&E) MODERNIZATION PRIORITY: Biotechnology

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop in silico methods for the design of carriers which can cross the blood brain barrier (BBB). This topic seeks development of (1) computational methods to aid in the design of targeted delivery vehicles which can cross the BBB and (2) application of these methods to successfully design and demonstrate working systems in vitro and in vivo.

DESCRIPTION: Biology is deemed a "new domain of warfare," and recent advances in biotechnology, albeit encouraging for the medical sector, have disturbing implications for military affairs in terms of new adversarial capabilities (Reference 1). Over the past 10 years, the People's Liberation Army has focused on the impact of biology for the future of warfare and is pursuing its military applications as a priority in China's national strategy of military-civil fusion. China and others are investing in biotechnologies, including gene editing and alternative viable means to both enhance and to decrement human performance through neuromodulation, to seek innovation that may precipitate military superiority. Current progress in the modulation of abnormal neural pathways through pharmacologic stimulation for uses as diverse as managing chronic pain (Reference 2), treating neurodegenerative disorders (Reference 3), and ameliorating symptoms associated with stress disorders (Reference 4) further underscores its potential. It is incumbent upon the U.S. Department of Defense to prepare for the eventuality that such research will yield operational tools that can be used on the battlefield and to develop technologies that preemptively obstruct their effects so that cognitive performance is maintained.

Determining means to access the brain successfully has been a premier challenge in the neurosciences (Reference 5). The blood-brain barrier (BBB), designed to shield the brain from toxins and maintain homeostasis, is a microvascular network separating the central nervous system (CNS) from peripheral blood circulation. The complexity of the BBB often limits therapeutic treatments by excluding drugs from reaching their target. Overcoming such limitations necessitates the design of carrier molecules who can cross the BBB and deliver therapeutics to the CNS. Recent work has highlighted the promise of nanocarriers (NC) and nanoparticles (NP) as well as viral and peptide shuttles and vectors (Reference 5) to deliver pharmacologic payloads. Efforts that feature design of nanocarriers and –particles are particularly encouraging. NC and NP can participate in multiple methods of transport, including passive diffusion, carrier-mediated transport, and transcytosis (Reference 6). NC and NP can be decorated with specific ligands to develop "Trojan horse" molecules which are able to bind BBB-specific receptors and enable delivery at the site of interest. However, additional work is needed to identify important design parameters and modifications that would lead reliably to BBB infiltration.

For the aforementioned purpose, in silico methods represent a cost-effective way of (1) accurately identifying and screening various factors affecting NC and NP ability to traverse the BBB and (2) down-selecting candidates for in vitro and in vivo studies to provide proof-of-concept that engineering strategies were successful. The overarching aim of the present topic is to develop algorithms appropriate for the aforementioned tasks, to synthesize promising candidates, and to test them in relevant in vitro and in vivo systems.

PHASE I: Leverage or develop predictive algorithms to identify favorable structures for targeted delivery of pharmalogic or other neuromodulation factors to the brain. In silico methods should evaluate, at minimum, size, charge, means and utility of functionalization, ability to carry relevant payloads, and potential for controlled release of payload(s) at the site(s) of interest. Performers will work jointly with the Government sponsor to incorporate other features as needed. Promising candidates will be synthesized and evaluated in appropriate in vitro models to provide preliminary demonstration of success (interpreted as ability to traverse the BBB proxy) as a foundation for Phase II work. Phase I deliverables will include (1) a final report and (2) a final meeting for discussion of selected in silico methods, means by which they were applied, outcomes of in vitro experiments, and plans for Phase II. The report will provide descriptions, performance, and validation of all models used, criteria for candidate down-selection, criteria for in vitro model selection, and detailed in vitro results. The report should also describe any developmental work, including model parameterization. Operating system, software (where applicable), and data compatibility should be specifically addressed, as should proposed location of the in silico product and plans for providing access to (future) potential users.

PHASE II: Phase II efforts will focus on iterative design improvements to the proof-of-concept approach developed during Phase I. The performer will mature in vitro model experiments, as needed, to provide a basis for animal testing. Candidates from in vitro testing will be evaluated in an animal model system to establish performance and toxicity profiles. The performer will identify weaknesses in performance that could be improved through additional in silico work and will codify /relay observations to the project officer. The phase II deliverables will be, among others, a final project review and a report detailing (1) description of the approach, including optimization techniques and performance outcomes, (2) testing and validation methods, and (3) advantages and disadvantages / limitations of the method as well as plans for developing an accessible user interface with any associated executables in accordance with proposed means of providing access to potential users as described in the Phase I final report.

PHASE III DUAL USE APPLICATIONS: In addition to implementing further improvements that would enhance use of the developed product by the sponsoring office, identify and exploit features that would be attractive for commercial or other private sector applications.

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KEYWORDS: Blood-Brain Barrier; Nanoparticles; Nanocarriers; Biotechnology Weaponization

DTRA224-003 TITLE: Non-Traditional Radiation Hardness Evaluation Tools for Complex Highly Integrated Microelectronic Components

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics; Space; Nuclear

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop and demonstrate non-traditional radiation effects characterization and radiation hardness evaluation approaches, tools, or methods for complex highly integrated components, such as System-on-a-Chip (SoC) or 3D integrated circuits.

DESCRIPTION: Department of Defense (DoD) systems seek to employ increasingly complex and highly integrated microelectronic components, such as system-on-a-chip (SOCs) and 3D integrated circuits for embedded high-performance computing and high-throughput processing in high radiation environments. Current SOCs are complex systems with multiple processing cores, multi-level caches, a mix of high-capacity and high-bandwidth memories, on-chip controllers for memory, network and other high-speed interfaces, on-chip hardware acceleration for encryption, graphics and digital signal processing, specialized security protocols, programmable fabrics; and more. This high degree of complexity and integration along with limited available design and manufacturing details for commercial SoCs, 3D ICs, and other highly integrated components makes conventional radiation testing and evaluation approaches for these components challenging. Some of these challenges include the programming and configuration of SOCs, isolating sub-component failures within them, and identifying the root causes of complex failure signatures.

DoD systems, especially space and strategic systems, must survive and operate in complex dynamic radiation environments that impact the performance and reliability of microelectronic components. Radiation effects of concern for highly integrated microelectronics include total ionizing dose, displacement damage, pulsed gamma/x-ray, as well as proton, heavy ion and neutron single event effects. Combined radiation effects for both natural and manmade environments are also of interest. Radiation testing of production components using simulated environments is the current standard practice for screening, characterization, and qualification of these components for DoD systems. Limited test time availability, high per component cost, and complex state space limit complete evaluation of these complex devices.

The development of evaluation approaches, methods, and tools to reduce test time, increase data collection and analysis of test data, or assist in screening and characterizing components without the use specialized high cost facilities would significantly increase the speed that state-of-the-art highly integrated microelectronic components could be inserted into DoD systems.
Potential approaches could include but are not limited to optical, electrical, or EM fault injection; thermal, stress, or other physical analysis; software tools for data collection and analysis including artificial intelligence machine learning approaches, novel uses of on-chip self-test or error detection codes, and modeling and simulation tools. Design and layout tools are not of interest to this topic, nor are efforts that are focused on the testing, evaluation, or qualification of a singular component.

PHASE I: The primary deliverable of phase 1 is a feasibility analysis or demonstration that the technique, tool, approach, or method is capable of evaluating radiation effects or radiation susceptibility and can be applied to a complex highly integrated microelectronic component, such as a SoC. Analysis or a proof of concept study on a simpler component or sub-component is acceptable for Phase 1. The primary deliverable of phase 1 is a feasibility analysis or demonstration that the technique, tool, approach, or method is capable of evaluating radiation effects or radiation susceptibility and can be applied to a complex highly integrated microelectronic component, such as a SoC. Analysis or a proof of concept study on a simpler component or sub-component is acceptable for Phase 1.

PHASE II: Phase 2 is development and refinement of the technique, tool, approach, or method from Phase 1. This could include more complex components, additional radiation effects, or increases in the scale and scope of data acquired and processed. Phase 2 should include a verification and validation approach tied to new or existing experimental radiation effects data on a single highly integrated component. Analysis of the potential reduction in test time or increased confidence of results should be included in Phase 2.

PHASE III DUAL USE APPLICATIONS: Phase 3 may involve additional refinement and generalization of the technique, tool, approach, or method with the intent to commercialize. Phase 3 may include automation, development of user interfaces, or integration of hardware and software. Verification and validation on multiple components would also be expected in Phase 3.

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KEYWORDS: Radiation Hardened; System on a Chip; 3D Integrated Circuit; Heterogeneous integration

DTRA224-004 TITLE: Novel Signature Collection Methods for Distributed Sensors

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence/ Machine Learning; Nuclear

TECHNOLOGY AREA(S): Information Systems; Nuclear; Sensors

OBJECTIVE: To investigate and demonstrate a proof-of-concept to leverage new and unique methods to harness the capabilities of distributed sensors such as mobile devices to improve the quality and quantity of data available on low-yield explosions. These techniques would provide more accurate and timely information on suspected nuclear-related activity in geographic areas of interest, as well as a greater volume of data. Demonstrate that the use of these novel data-collection methods would increase the volume and quality of the opportunistic signatures collected during low-yield explosive events.

DESCRIPTION: Cellular devices have a number of sensors that are required to enable functionality and detect environmental conditions, such as accelerometers, magnetometers, and GPS. Accelerometer data can be used to detect seismic activity arising from natural events such as earthquakes, or human-caused events such as explosions. One of the well-known apps for collecting seismic data is MyShake, developed at Lawrence Livermore National Lab (LLNL), and Google has also been working with LLNL to develop algorithms for Android devices to use as mini-seismometers to detect earthquakes. However, DoD is limited in the availability of reliable and consistent data-collection methods and data-collection opportunities for low-yield explosive events, especially in specific geographic areas of interest.
This proposed R&D effort will determine the extent to which such sensors can be leveraged in new and unique ways to generate data capable of informing methods for event detection, location, and characterization and associated indicators and warnings. For example, the development of new software development kits to collect publicly available information. This is of particular interest for detecting and locating suspected low-yield underground nuclear explosions. This proposed work differs from existing applications such as MyShake in that it would not rely upon a specific app being downloaded or on the use of specific hardware. This project also focuses on the detection, discrimination, and analysis of low-yield underground explosions as opposed to earthquake warnings. This work has the potential for multiple DoD uses beyond event characterization. For example, these methodologies could be used for navigating in GPS-denied environments, characterization of structures, and collection and analysis of other signatures of operational use. These methods could also be used to characterize and assess unusual events such as the Beirut explosion in August 2020.

PHASE I: Define the proposed concept and develop key technical milestones for Phase II. Perform an analysis of accelerometers in various devices available in geographical areas of interest and the feasibility to implement software development kits. Determine the technical feasibility to access the desired data at scale. By the end of Phase I, the performer will have developed a conceptual design for the new data collection methodologies and develop a roadmap for implementation in Phase II.

PHASE II: Based on the Phase I conceptual design, develop, test, and demonstrate the proposed novel data collection methodology in at least one geographic area of interest to DoD. Implement artificial intelligence algorithms to process and analyze data. Conduct assessments on the data collected to determine quality to be useful.

PHASE III DUAL USE APPLICATIONS: Further develop and implement the methodologies from Phase II to expand data collection to additional geographic areas of interest. Develop a plan to apply machine-learning techniques to the large volumes of data collected via the implementation of the new methodologies developed in Phase II to identify and characterize signatures of interest globally. Conduct field tests of data acquisition, remote sensing, and data analysis in different geographic areas

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KEYWORDS: accelerometers; machine learning; remote sensing; artificial intelligence; seismic; publicly available information

DTRA224-005 TITLE: Optically-based Standoff Diagnostic to Interrogate the Evolution of Liquid Ejected from Containers Impacted by Shock and Fragments

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements

TECHNOLOGY AREA(S): Sensors; Weapons

OBJECTIVE: The objective of this effort is to develop an optically-based standoff diagnostic to interrogate the evolution of liquid ejected from containers impacted by shock and fragments in a detonation environment.

DESCRIPTION: In agent defeat scenarios, fragment and shock loading on liquid-filled containers results in ejection of the fluid into the weapons effects environment. Simplified open-air tests have been conducted that control the fragment loading (number of fragments, size, and velocity); however, diagnostics are typically limited to internal pressure, container acceleration, and estimates of general fluid spray characteristics (e.g., spray velocity, spray angle) via high speed video. Some capabilities exist for point measurement of particle size distribution (PSD) within the fluid spray, PSD at the spray edges, or x-ray imaging of the total fluid field, with limited ability to meet test objectives due to sampling rate, resolution / dynamic range for particle sizing, instrument saturation effects and / or extrapolation to the full non-homogenous fluid field.

Detailed characterization of the temporal and spatial distribution of ejected fluid is not readily possible. Metrics of interest include mass fraction aerosolized, particle size distribution, and concentration – all temporally and spatially resolved and residing in a rapidly evolving environment. Challenges include non-homogenous fluid fields that include distributions of small (~10 um) to large (~2,000+ um) aerosols and bulk material, transient timescales (<200 ms), and optically opaque and destructive (e.g., high temperature and pressure, fragments, etc.) environments. Diagnostics characterizing the early time evolution of material ejected from containers is of high interest. The diagnostic should be able to clearly differentiate between agent material and non-agent material (e.g., water). It should be noted that the shock break up of aerosols and bulk fluid in these scenarios is also of interest. At various ranges from the weapon, times of arrival of initial shocks and fragments may vary widely (and even cross over), resulting in potential shock interactions ranging from early to late in the spray evolution.

The ultimate goal of this work is to improve and validate both Computational Fluid Dynamics (CFD) and fast-running models for a wide range of container types and shock/fragment impact conditions.
DTRA has developed explosive disseminators of various sizes (20mL, 60mL, 250mL, and 1000mL) which can emulate the directed spray of interest without the requirement for flying fragments. The disseminator designs will be available for Phase I and Phase II projects.

PHASE I: 1) Develop an optically-based diagnostic capability for characterizing the evolution of liquid ejected from containers impacted by shock and fragments in a detonation environment. 2) Demonstrate the concept in a laboratory-based simulated environment.

PHASE II: 1) Produce a breadboard capability that is hardenable/scalable for field-testing.
2) Demonstrate performance in a small to mid-scale detonation test. Stand-alone capabilities or those that are orthogonal to existing (non-optical) capabilities which might enhance statistical collection are of interest. Hardening measures and/or beam transport will need to be considered.

PHASE III DUAL USE APPLICATIONS: Team up with a DoD Laboratory or commercial partner to develop a commercial instrument for military applications of interest to DTRA and the DoD, or for applications of interest to the petroleum and chemical industries.

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KEYWORDS: Liquid Agents; Lasers; Spectroscopy; Weapons