Broad Agency Announcement

Enhancing Quantum Sensor Technologies with Rydberg Atoms (EQSTRA)

DEFENSE SCIENCES OFFICE (DSO)

HR001124S0031

May 31, 2024

This publication constitutes a Broad Agency Announcement (BAA) as contemplated in Federal Acquisition Regulation (FAR) 6.102(d)(2) and 35.016 and 2 CFR § 200.203. Any resultant award negotiations will follow all pertinent law and regulation, and any negotiations and/or awards for procurement contracts will use procedures under FAR 15.4, Contract Pricing, as specified in the BAA.

OVERVIEW INFORMATION:

- **Federal Agency Name** – Defense Advanced Research Projects Agency (DARPA), Defense Sciences Office (DSO)
- **Funding Opportunity Title** – Enhancing Quantum Sensor Technologies with Rydberg Atoms (EQSTRA)
- **Announcement Type –** Initial Announcement
- **Funding Opportunity Number –** HR001124S0031
- **Assistance Listing Number:** 12.910 Research and Technology Development
- **Dates/Time -** All Times are Eastern Time Zone (ET)
  - Posting Date: May 31, 2024
  - Proposers Day: June 3, 2024
  - Proposal Abstract Due Date: June 18, 2024, at 4:00 p.m.
  - Question Submittal Closed: July 22, 2024, at 4:00 p.m.
  - Proposal Due Date: July 30, 2024 at 4:00 PM

- **Anticipated Individual Awards** – Multiple awards are anticipated
- **Types of Instruments that May be Awarded** – Cooperative Agreements, Procurement Contracts, and Other Transaction Agreements for Prototype
- **NAICS Code**: 541715
- **Agency Contact**
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Section I: Funding Opportunity Description

The Defense Sciences Office (DSO) at the Defense Advanced Research Projects Agency (DARPA) is soliciting innovative proposals that significantly advance the performance, capabilities and the Technology Readiness Level (TRL) of atomic vapor sensors for electric field sensing, imaging, communications, and quantum information science (QIS). Proposed research should investigate innovative approaches enabling revolutionary advances in science, devices, or systems. Specifically excluded is research that primarily results in evolutionary improvements to the existing state of practice.

A. Background

Electromagnetic sensors based on thermal atomic vapors offer prospects of compact, calibration-free and low size, weight, and power (SWaP) devices that exhibit low drift, and quantum-limited accuracy and sensitivity. An extensive and sophisticated toolbox of techniques was developed for the quantum state preparation, manipulation, and measurement of ground-state properties of atomic vapors for various applications in Quantum Information Science (QIS). This has enabled the progress of vapor-based technologies such as compact atomic clocks, nuclear magnetic gyroscopes, and magnetometers to high levels of technological maturity.

Technologies based on Rydberg atomic vapors, while more nascent, promise to enable similarly disruptive capabilities in radio frequency (RF) electrometry, imaging, and communications. However, in contrast to previously developed vapor-based devices, Rydberg-based technologies pose new challenges arising from the higher sensitivity, fragility, and technical complexities associated with robust quantum-limited manipulation of Rydberg states. These challenges, ranging from the fundamental to the technical, have impeded rapid maturation of Rydberg-based concept demonstrators to higher technology readiness levels (TRLs). Building upon extensive efforts by the wider atomic physics community and within several DARPA programs to elucidate these various challenges, this solicitation seeks to (i) enhance the capabilities of Rydberg-based technologies extending into the millimeter-wave domain, (ii) accelerate developing Rydberg-based technologies to higher TRL and quantum-limited performance, and (iii) establish a broad foundation of analyses, feasibility studies, and proof-of-concept application studies of disruptive opportunities engendered by Rydberg-based vapor technologies for Department of Defense-relevant applications including quantum-enhanced sensing, imaging, and communications.

B. Program Description/Scope

The EQSTRA solicitation seeks to augment ongoing efforts within the DARPA Science of Atomic Vapors for New Technologies (SAVaNT) program to advance the performance, capabilities, and application landscape of Rydberg-vapor technologies for QIS, quantum-enhanced electrometry, imaging, and communications.

As originally conceived, the SAVaNT program sought to develop techniques to mitigate the effects of thermal motion and decoherence within broad categories of vapor-based sensing technologies. Leveraging such techniques, the program sought to demonstrate beyond State-of-the-Art sensitivity, accuracy, and detection bandwidth in vapor-based magnetometers and electrometers.[1]

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[1] www.darpa.mil/program/science-of-atomic-vapors-for-new-technologies

Lastly, the program aimed to advance the integration of Rydberg-based electrometers to demonstrate a table-top physics package.

Substantial progress towards these goals during the first phase of the program, both within the program and within the wider quantum sensing community, has motivated additional scientific and technological goals. Particularly, there has been rapid progress towards higher performance Rydberg-based sensors, the development of multiphoton Doppler-insensitive techniques to mitigate effects of thermal motion, and novel all-optical sensing modalities. Various efforts have also clarified disruptive opportunities of such sensors over electro-optic, antenna-based, or plasmonic modalities. Lastly, progress was made in the elucidation of various fundamental and technical challenges that currently impede the attainment of quantum-limited sensor performance, and the development of integrated, low-SWaP devices. By leveraging the results of such ongoing efforts, this solicitation seeks innovative proposals to address these new opportunities and challenges. Specifically, proposals are sought in the following Focus Areas (FA):

- FA 1 – <u>Development of atomically-referenced tunable, narrow linewidth sources of terahertz radiation.</u>
    - In conjunction with Rydberg-vapor electrometers being developed in the SAVaNT program, this FA will enable calibration-free, and matched transmitter-receiver systems beyond the millimeter-wave regime.
- FA 2 – <u>Development of low-SWaP and integrated Rydberg electrometers.</u>
    - This FA seeks to develop components and enabling technologies to reduce the SWaP metrics of integrated Rydberg-based RF receivers. This includes, but is not limited to, developing chip-scale tunable optical sources for the state preparation and readout of Rydberg electrometers over a wide carrier band extending into the millimeter-wave domain.
- FA 3 – <u>Development of wafer-scale vapor cells for wideband Rydberg electrometry.</u>
    - This FA seeks to develop wafer-scale atomic vapor cells with the requisite homogeneity, manufacturability, and optical quality to enable higher performance and more robust Rydberg-based electrometry.
- <u>FA 4</u> – <u>Concept and feasibility studies of Rydberg-based quantum technologies.</u>
    - Studies of the application space that would be engendered by developing compact, high-performance, and quantum-limited Rydberg transmit-receive systems for wideband communications, imaging, and spectrum awareness.

The description and goals of each focus area is detailed in section C.

C. Focus Area Descriptions

This solicitation contains four FAs each with their own set of technical risks and challenges. Each proposal may respond to one FA. Entities who seek to respond to more than one FA will need to submit independent proposals. As of the date of publication of this BAA, it is anticipated FAs 1 and 4 may generate information subject to Controlled Unclassified Information (CUI) or Controlled Technical Information (CTI) controls. Potential award instruments for proposals containing CUI will be limited to Procurement Contracts or Other Transactions. Proposers should review Attachment H: Controlled Unclassified Information (CUI) Guide to assist in proposal preparation.

FA 1: Development of atomically-referenced tunable, narrow linewidth sources of terahertz radiation.

This FA seeks to augment ongoing efforts within the SAVaNT program in Rydberg-based sensing by developing stable, tunable, and narrow linewidth sources of terahertz radiation to enable atomically-referenced and matched transmitter-receiver systems for applications including terahertz spectroscopy, frequency-agile imaging, communications, and metrology. An oft-touted basis of the disruptive nature of Rydberg-based electrometers is the immense span of frequencies that can, in principle, be detected within the same sensor. By merely preparing the atoms in different Rydberg states, the atomic vapor can be made responsive to electromagnetic radiation at frequencies ranging from the MHz (HF) to the terahertz range (THF). In recent years, these capabilities of Rydberg sensors have been extensively studied in the radiofrequency and microwave regimes. In contrast, the terahertz domain has been less explored in this context. While this latter domain has been the focus of attention for applications including imaging, telecommunications, and spectroscopy,[2] the sophistication of technologies in this regime is still at its infancy – dubbed the "terahertz gap." As such, the combination of quantum-limited sensitivity, wide tuning range, and high frequency resolution offered by Rydberg sensors presents disruptive opportunities for a range of applications in this space.[3] Additionally, these applications can be significantly bolstered by co-developing of tunable sources of terahertz radiation.

Despite the wide landscape of potential sources of terahertz radiation,[4] the combination of attributes sought by this solicitation pose unique challenges. Electronic techniques to generate radiation in this frequency band often rely on nonlinear frequency mixing chains[5] that, while capable of significant output power, suffer from high levels of phase noise, reduced spectral range, and high distortion – effects limiting the use of such techniques for spectroscopy, imaging, and communications. In contrast, all-optical techniques including quantum cascade lasers, difference-frequency generation and optical down-conversion within compact, chip-integrated and nanoplasmonic architectures have made rapid progress in recent years.[6] Such integrated photonic techniques are naturally compatible with rapid intensity, phase, or polarization modulation techniques for various telecommunication protocols. To meet the requirements of this solicitation, these photonic architectures will need to be complemented with long-term stabilization to an

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[2] P. U. Jepsen et al, *Terahertz spectroscopy and imaging – modern techniques and applications*, Laser Phot. Rev. 5, 124 (2011); A. Leitenstorfer et al, The 2023 terahertz science and technology roadmap, J. Phys. D Appl. Phys. 56, 223001 (2023).

[3] L. A. Downes et al, Ultra-high-speed terahertz imaging at kilohertz frame rates using atomic vapor, Phys. Rev. X 10, 011027 (2020).

[4] R. A. Lewis, A review of terahertz sources, J. Phys. D Appl. Phys. 47, 374001 (2014).

[5] See, for example, K. Kasagi et al, Large-scale array of resonant-tunneling-diode terahertz oscillators for high output power at 1 THz, J. Appl. Phys. 125, 151601 (2019); P. Hu et al, Demonstration of a watt-level traveling wave tube amplifier operating above 0.30 THz, IEEE Electron Dev. Lett. 40, 973 (2019); K. M. Leong et al, 850 GHz receiver and transmitter front-ends using InP HEMT, IEEE Trans. Terahertz Sci. Tech. 7, 466 (2017).

[6] See, for example, B. Wang et al, Towards high-power, high-coherence, integrated photonic mmWave platform with microcavity solitons, Light: Sci. Appl. 10, 4 (2021); N. Kuse et al, Low phase noise THz generation from a fiber-referenced Kerr microresonator soliton comb, Comm. Phys. 5, 312 (2022); L. Djevahirdjian et al, Frequency stable and low phase noise THz synthesis for precision spectroscopy, Nature Comm. 14, 7162 (2023); D. Shin et al, Photonic comb-rooted synthesis of ultra-stable terahertz frequencies, Nature Comm. 14, 790 (2023); W. Wang et al, Coherent terahertz radiation with 2.8-octave tunability through chip-scale photomixed microresonator optical parametric oscillation, Nature Comm. 13, 5123 (2022).

atomic frequency reference. Other intriguing prospects include harnessing Rydberg vapors for collective emission in a manner that would be naturally matched to the atomic receivers. These concepts build upon substantial theoretical development of Rydberg masers and preliminary proof-of-concept demonstrations of collective emission by Rydberg vapors in the terahertz regime.[7] While this would ensure the requisite tunability, stability, and automatic matching between the emission and absorption transitions, proposals will need to justify their device concept is capable of generating sufficient output power to meet the program metrics.

Proposals to this FA must contain a detailed discussion of the proposed terahertz source; the proposed device specifications (e.g., tunability, modulation capabilities, requisite control architectures and cumulative SWaP), in addition to the program metrics for this FA (e.g., output power, phase noise or linewidth, and tunable range of output frequency) that will be demonstrated during the period of performance; proposed testing and characterization demonstrations that will be performed to demonstrate the requisite output power, tuning range, and linewidth; and, potential challenges and risk mitigation strategies.

FA 2: Development of low-SWaP and integrated photonics for Rydberg electrometers.
This FA seeks to accelerate the development of enabling components and technologies required for integrated, compact and low-SWaP Rydberg-based sensors. Presently, the SWaP metrics of Rydberg-based sensors tend to be dominated by the requirements of the laser systems and associated control architectures. As such, the key components in need of further development are compact, integrated and/or on-chip laser sources, and on-chip photonics and stabilization/control architectures for wideband and frequency-agile Rydberg spectroscopy. Unlike chip-scale atomic clocks (CSAC) or alkali magnetometers, Rydberg-based sensors require significantly more complex photonic infrastructure.[8] These requirements arise from the multiphoton nature of Doppler-insensitive Rydberg spectroscopy, the span of optical transitions ranging from the visible to the mid-wave infrared for Rydberg state preparation and readout, the larger optical powers required to saturate the weak Rydberg transitions, and the narrow linewidths and long-term stability required to approach fundamental limits of performance. To date, much of the rapid progress on Rydberg-based technologies has been enabled by bulk laser systems exhibiting the requisite levels of performance, albeit at the expense of large SWaP-c metrics.

Concomitantly, there has been extensive progress in the field of integrated, on-chip photonic and optoelectronic architectures that can be leveraged to obtain similar performance but on far smaller and more robust device footprints. Recent developments include a range of on-chip narrow-linewidth laser sources and amplifiers at wavelengths relevant to Rydberg spectroscopy;[9]

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[7] See, for example, M. Lam et al, Directional terahertz generation in hot Rb vapor excited to a Rydberg state, Opt. Lett. 46, 1017 (2021); L. Moi et al, Rydberg-atom masers. I. A theoretical and experimental study of super-radiant systems in the millimeter-wave domain, Phys. Rev. A 27, 2043 (1983).

[8] See, for example, R. Legaie et al, *Sub-kilohertz excitation lasers for quantum information processing with Rydberg atoms*, J. Opt. Soc. Am. B 35, 892 (2018); M. L. Day et al, *Limits on qatomic qubit control from laser noise*, npj Quant. Inf. 8, 72 (2022).

[9] A. Boes et al, *Lithium niobate photonics: unlocking the electromagnetic spectrum*, Science 379, 40 (2023); Z. Zhang et al, *Photonic integration platform for rubidium sensors and beyond*, Optica 10, 752 (2023); M. Corato-Zanarella et al, *Widely tunable and narrow-linewidth chip-scale lasers from near-ultraviolet to near-infrared wavelengths*, Nature Photonics 17, 157 (2023); Y. Liu et al, *A fully hybrid integrated erbium-based laser*,

microcomb-based photonic circuits that can be harnessed for the stabilization, distribution, and wideband addressability of Rydberg states for electrometry; and low-latency optical routing signal processing architectures. Proposals on the development of compact, low-SWaP, and integrated photonic platforms for Rydberg electrometry are in scope of this focus area.

FA 2 proposals should contain a detailed discussion of the integrated photonic laser/architecture; the relevant device specifications (e.g., output power, phase noise or linewidth, and requisite control architectures); proposed testing and benchmarking demonstrations that will be performed to demonstrate the requisite spectroscopic range, stability, and sensitivity for Rydberg electrometry; and, potential challenges and risk mitigation strategies. Proposals should contain a detailed assessment of the capabilities of their proposed laser system against the requirements of wideband Rydberg electrometry in terms of the requisite powers for the various multiphoton Rydberg excitation schemes, the frequency agility of the laser system to enable wideband sensing, modulation techniques and protocols that would be compatible with the proposed laser system, the proposed phase noise/linewidth of the system and the anticipated sensor performance (sensitivity, instantaneous bandwidth, frequency range of electrometry) this system would enable. Proposers to this FA should justify how the performance of the proposed photonic architecture is consistent with the SAVaNT program metrics for eventual Rydberg sensor performance (Electric field sensitivity, instantaneous bandwidth). This FA seeks to enable compact Rydberg receivers with a volume of <10 liters and a power consumption of < 50 W. Proposers should incorporate these metrics into their FA 2 proposal, and justify how their proposed photonic architecture, in conjunction with SoA stabilization and control architectures, can meet this SWaP metric.

<u>FA3: Development of wafer-scale vapor cells for wideband Rydberg electrometry.</u>

This FA seeks to develop wafer-scale atomic vapor cells with the requisite homogeneity, manufacturability, and optical quality to enable higher performance and more robust Rydberg-based electrometry. Current SoA Rydberg sensors typically employ glass-blown vapor cells to achieve the best performance. However, such cells suffer from large process variations, poor homogeneity, and limited scope for miniaturization. Microfabricated alkali vapor cells have undergone extensive development in the context of CSACs and atomic magnetometers.[10] However, these cells continue to suffer from numerous issues including manufacturing variability, contamination, optical quality, surface charging effects, and associated long-term drifts in performance. In the context of Rydberg-based sensors, these issues assume increased importance due to the extreme sensitivity of Rydberg states to collisional relaxation, impurity contamination,

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arXiv:2305.03652 (2023); J. Yang et al, *Titanium:Sapphire-on-insulator for broadband tunable lasers and high-power amplifiers*, arXiv:2312.00256 (2023); J. C. Hill et al, *Intra-cavity frequency-doubled VECSEL system for narrow linewidth Rydberg EIT spectroscopy*, Opt. Exp. 30, 41408 (2022); J. N. Tinsley et al, *Watt-level blue light for precision spectroscopy, laser cooling and trapping of strontium and cadmium atoms*, Opt. Exp. 29, 25462 (2021); N. Chauhan et al, *Visible light photonic integrated Brillouin laser*, Nature Comm. 12, 4685 (2021); W. Loh et al, *A Brillouin laser optical atomic clock*, arXiv:2001.06429 (2020).

[10] See, for example, J. Kitching, *Chip-scale atomic devices*, Appl. Phys. Rev. 5, 108 (2018); S. Karlen et al, *Lifetime assessment of RbN_3-filled MEMS atomic vapor cells with Al_2O_3 coating*, Opt. Exp. 25, 2187 (2017); Z. L. Newman et al, *Architecture for the photonic integration of an optical atomic clock*, Optica 6, 680 (2019); J. P. McGilligan et al, *Micro-fabricated components for cold atom sensors*, Rev. Sci. Instrum. 93, 091101 (2022); H. Nishino et al, *Micro-fabricated vapor cells with sealed Rb atoms by distillation at wafer level and two-step bonding for miniature atomic clocks*, Opt. Exp. 29, 44316 (2021).

electromagnetic distortion, charge accumulation on cell walls, and a host of other issues leading to temporal drifts, variability, distortions and degradation of performance. Many, if not all, of these issues have a greater impact on sensor performance at higher RF frequencies (or correspondingly smaller wavelengths) – a regime in which such issues cannot be mitigated merely by increasing the volume of the cell. On the flip side, this sensitivity also, in principle, enables rigorous wafer-scale calibration, diagnostics, and optimization of fabrication processes by using *in situ* Rydberg spectroscopy to study and quantify these various mechanisms.[11] Proposals on wafer-scale development, production, and characterization of atomic vapor cells for Rydberg electrometry are in scope of this FA. FA 3 proposals should present a compelling discussion of the innovative nature of the proposed concept; consideration of the various factors that currently lead to degradation or variability of Rydberg sensor performance such as EM distortions, charge accumulation, contamination, drifts, and manufacturing variability; and strategies to overcome these current limitations to enable robust, accurate and sensitive Rydberg electrometry extending into the millimeter wave domain.

Proposals to this Focus Area should contain clear descriptions of the various characterization and benchmarking tests that will be performed to quantify the performance of the proposed vapor cells. These tests should address factors including, but not limited to, cell-to-cell consistency of alkali filling and vapor purity; anticipated distortions of the EM fields by cell walls; potential etaloning effects; and aging and anticipated variations in cell characteristics following thermal recycling. The proposal should contain quantitative proposer-defined metrics for each of the above factors. DARPA may choose to perform Independent Verification and Validation (IV&V) tests of the fabricated cells by Government teams to verify performance against the proposed metrics.

FA 4: Concept and feasibility studies of Rydberg-based quantum technologies.

Rydberg atoms respond to electromagnetic radiation in a manner distinct from electro-optic or antenna-based electronic modalities.[12] This enables disruptive applications, novel modalities, and new opportunities in the broad areas of quantum-enhanced electrometry, spectrally-resolved imaging, communications, and spectrum analysis. This FA seeks to develop conceptual foundations, proof-of-concept studies, and feasibility analyses of novel application landscapes engendered by continued developments in Rydberg quantum technologies. FA 4 proposals should contain a detailed description of the problem area, the analysis that will be performed to demonstrate Rydberg-based capabilities in this area, and comparisons to current SoA capabilities in this area to justify the potential for disruption using Rydberg-based technologies. It is

[11] See, for example, M. Hasegawa et al, *Effects of getters on hermetically sealed micromachined cesium-neon cells for atomic clocks*, J. Micromech. MicroEng. 23, 055022 (2013); A. Tauschinsky et al, *Spatially resolved excitation of Rydberg atoms and surface effects on an atom chip*, Phys. Rev. A 81, 063411 (2010); J. Naber et al, *Adsorbate dynamics on a silica-coated gold surface measured by Rydberg Stark spectroscopy*, J. Phys. B: At. Mol. Opt. Phys. 49, 094005 (2016); J. A. Sedlacek et al, *Electric field cancellation on Quartz by Rb Adsorbate-Induced negative electron affinity*, Phys. Rev. Lett. 116, 133201 (2016).

[12] See, for example, G. Santamaria-Botello et al, *Comparison of noise temperature of Rydberg-atom and electronic microwave receivers*, arXiv:2209.00908 (2022); M. Menchetti et al, *Digitally encoded RF to optical data transfer using excited Rb without the use of a local oscillator*, J. Appl. Phys. 133, 014401 (2023); L. Zhang et al, *Ultra-Wide dual-band Rydberg atomic receiver based on space division multiplexing RF-chip modules*, j.chip.2024.100089 (2024); B. Liu et al, *Electric field measurement and application based on Rydberg atoms*, Electromag. Sci. 2, 0020151 (2023).

insufficient to justify such potential applications with simple estimates of quantum sensitivity limits of Rydberg-based sensors. Rather, such comparisons should include detailed analyses of SWaP requirements and current restrictions; current limitations of conventional approaches; current technical and fundamental limitations of Rydberg-based sensors; and techniques (as applicable) to overcome such limitations in the near-term. The proposal may include proof-of-concept experimental demonstrations of the proposed disruptive applications.

D. Schedule/Milestones

The EQSTRA program consists of four independent FAs proceeding in parallel. Each FA will be a 24-month effort. Proposers seeking awards for multiple FAs must submit stand-alone proposals for each. Proposers should specify the research and technology development schedule for the full period of performance. The Statement of Work (SOW) must provide a detailed task breakdown, citing specific tasks and their connection to interim milestones and metrics, as applicable. Proposers should provide a technical and programmatic strategy conforming to the entire program schedule and presents an aggressive plan to fully address all program goals, metrics, milestones, and deliverables. The task structure must be consistent across the proposed schedule, SOW, and cost volume.

Schedules will be synchronized across performers, as required, and monitored/revised as necessary throughout the program. A target start date of January 2025 may be assumed for planning purposes. In light of the aggressive schedule and substantial ongoing efforts within the SAVaNT program complementary to the goals of this effort, proposers are encouraged, but not required, to collaborate with existing teams within the SAVaNT program in order to achieve their proposed metrics and goals.

The following metrics will serve as evaluation points during the course of the program, along with any additional metrics included in the proposal; proposers should incorporate these into their SOW. Performers' progress will be measured against the metrics shown in Table 1. Program reviews will take place at months 12 and 20 to assess performer progress against these metrics.

Table 1. Progress Metrics

Focus Area	EQSTRA Metrics
FA1: Terahertz source output power	> 5 mW
FA1: Terahertz source tunable range	100 GHz – 800 GHz
FA1: Terahertz source linewidth	< 1 MHz
FA2: Photonics & Control Package SWaP	< 10 L, < 50 W
FA3: Wafer-scale vapor cell development	Proposer-defined metrics
FA4: Rydberg Application Studies	Proposer-defined metrics

Meetings and Travel

- To foster collaboration between teams and disseminate program developments, a two-day Principal Investigator (PI) meeting will be held approximately every six months with locations split between the East and West Coasts of the United States. For budgeting purposes, plan for five two-day meetings over the course of 24 months: three meetings in the Washington, D.C. area and two meetings in the San Francisco, CA area.

- All proposals must also include the following meetings in the proposed schedule and costs:
    - Regular teleconference meetings will be scheduled with the Government team for progress reporting as well as problem identification and mitigation.
    - Proposers should anticipate at least one site visit per year by the DARPA Program Manager during which they will have the opportunity to demonstrate progress towards agreed-upon milestones.

E. Deliverables

Performers will be expected to provide at a minimum the following deliverables:

- Comprehensive quarterly technical reports due within ten days of the end of the given quarter, describing progress made on the specific milestones as laid out in the SOW.
- A phase completion report submitted within 30 days of the end of each phase, summarizing the research done.
- Other negotiated deliverables specific to the objectives of the individual efforts. These may include registered reports; experimental protocols; publications; data management plan; intermediate and final versions of software libraries, code, and APIs, including documentation and user manuals; and/or a comprehensive assemblage of design documents, models, modeling data and results, and model validation data.

Section II: Evaluation Criteria

- Proposals will be evaluated using the following criteria listed in ***descending order of importance***: Overall Scientific and Technical Merit; Potential Contribution and Relevance to the DARPA Mission; and Cost and Schedule Realism.

  - **Overall Scientific and Technical Merit**: The proposed technical approach is innovative, feasible, achievable, and complete. Detailed technical rationale is provided delineating why the proposed approach can achieve the program goals and metrics. The proposed technical team has the expertise and experience to accomplish the proposed tasks. Task descriptions and associated technical elements provided are complete and logically sequenced with all proposed deliverables clearly defined so the final outcome of the award's work achieves the goal. The proposal identifies major technical risks, and planned mitigation efforts are clearly defined and feasible.

  - **Potential Contribution and Relevance to the DARPA Mission**: The potential contributions of the proposed effort bolster the national security technology base and support DARPA's mission to make pivotal early technology investments that create or prevent technological surprise. The proposed intellectual property restrictions (if any) will not significantly impact the Government's ability to transition the technology.

  - **Cost and Schedule Realism**: The proposed costs and schedule are realistic for the technical and management approach and accurately reflect the technical goals and objectives of the solicitation. All proposed labor, material, and travel costs are necessary to achieve the program metrics, consistent with the proposer's statement of work, and reflect a sufficient understanding of the costs and level of effort needed to successfully accomplish the proposed technical approach. The costs for the prime proposer and proposed subawardees are substantiated by the details provided in the proposal (e.g., the type and number of labor hours proposed per task, the types and quantities of materials, equipment and fabrication costs, travel, and any other applicable costs and the basis for the estimates). The proposed schedule aggressively pursues performance metrics in an efficient time frame that accurately accounts for the anticipated workload.

    It is expected the effort will leverage all available, relevant, prior research to obtain the maximum benefit from the available funding. For proposals containing cost share, the proposer has provided sufficient rationale regarding the appropriateness of the cost share arrangement, relative to the objectives of the proposed solution (e.g., high likelihood of commercial application, etc.).

- Unless otherwise specified in this announcement, for additional information on how DARPA reviews and evaluates proposals through the Scientific Review Process, please visit: Proposer Instructions: General Terms and Conditions.

Section III: Submission Information

- This announcement allows for multiple award instrument types to be awarded to include Procurement Contracts, Cooperative Agreements, or Other Transaction agreements for Prototypes. Some award instrument types have specific cost-sharing requirements. The following websites are incorporated by reference and contain additional information regarding overall proposer instructions, general terms and conditions, and each specific award instrument type.

  Proposers must review the following links below:

  - **Proposer Instructions and General Terms and Conditions**: Proposer Instructions: General Terms and Conditions
  - **Procurement Contracts**: Proposer Instructions: Procurement Contracts
  - **Cooperative Agreements**: Proposer Instructions: Grants/Cooperative Agreements
  - **Other Transaction agreements**: Proposer Instructions: Other Transactions

- This announcement contains an abstract phase. Abstracts are due June 18, 2024, at 4:00 p.m. as stated in the Overview section. Abstracts are strongly encouraged but not required. Additional instructions for abstract submission are contained within **Attachments A and B**. (Regardless of instrument type desired, all abstracts must be submitted through the Broad Agency Announcement Tool (BAAT.) For detailed information on how to submit to BAAT, visit the "Unclassified Submission Instructions" section at Proposer Instructions: General Terms and Conditions.

- Full proposals are due July 30, 2024, at 4:00 p.m. as stated in the Overview section.

- **Attachments C, D, E, and F** contain specific instructions and templates and constitute a full proposal submission for proposers requesting either a Procurement Contract or Other Transactions for Protoype.

- **Attachments C, D, and F** contain specific instructions and templates and constitute a full proposal submission for proposers requesting a Cooperative Agreement.

- Please visit Proposer Instructions: General Terms and Conditions for general Terms and Conditions for all requested contract types. Visit Proposer Instructions: Procurement Contracts for submission instructions for proposers requesting Procurement Contracts. Visit Proposer Instructions: Other Transactions for submission instructions for proposers requesting Other Transactions. Visit Proposer Instructions: Grants/Cooperative Agreements for submission instructions for proposers requesting Cooperative Agreements. (Proposers requesting Procurement Contracts or Other Transactions for Prototype must submit proposals through the Broad Agency Announcement Tool. If requesting a Cooperative Agreement proposals must be submitted through grants.gov.)

- **BAA Attachments**:
  - **(template required if submitting abstract) Attachment A**: Abstract Summary Slide Template

- **(template required if submitting abstract) Attachment B**: Abstract Instructions and Template
- **(template required) Attachment C**: Proposal Summary Slide Template
- **(template required) Attachment D**: Proposal Instructions and Volume I Template (Technical and Management)
- **(template required for proposers requesting Procurement Contracts or Other Transactions for Prototype) Attachment E**: Proposal Instructions and Volume II Template (Cost)
- **(template required) Attachment F**: MS Excel™ DARPA Standard Cost Proposal Spreadsheet
- **(informational) Attachment G**: Sample Associate Contractor Agreement (ACA)
- **(informational) Attachment H**: Controlled Unclassified Information (CUI) Guide

Section IV: Special Considerations

- This announcement, stated attachments, and websites incorporated by reference constitute the entire solicitation. In the event of a discrepancy between the announcement, attachments, or websites, the announcement takes precedence.

- All responsible sources capable of satisfying the Government's needs, including both U.S. and non-U.S. sources, may submit a proposal DARPA will consider. Historically Black Colleges and Universities, small businesses, small disadvantaged businesses and minority institutions are encouraged to submit proposals and join others in submitting proposals; however, no portion of this announcement will be set aside for these organizations' participation due to the impracticality of reserving discrete or severable areas of this research for exclusive competition among these entities. Non-U.S. organizations and/or individuals may participate to the extent that such participants comply with any necessary nondisclosure agreements, security regulations, export control laws, and other governing statutes applicable under the circumstances.

- As of the time of publication of this solicitation, all proposal submissions are anticipated to be unclassified.

- This program is subject to Attachment G: Sample Associate Contractor Agreement.

- This program is subject to Attachment H: Controlled Unclassified Information (CUI) Guide. All individuals accessing CUI agree to protect CUI in accordance with *DoD Instruction 5200.48 CONTROLLED UNCLASSIFIED INFORMATION (CUI)* and *NIST Special Publication 800-171 Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations*.

- Federally Funded Research and Development Centers, University Affiliated Research Centers, and Government entities interested in participating in the EQSTRA program or proposing to this BAA should first contact the agency point of contact listed in the Overview section prior to the Abstract due date to discuss eligibility. Complete information regarding eligibility can be found at Proposer Instructions: General Terms and Conditions.

- As of the date of publication of this solicitation, the Government expects program goals as described herein may be met by proposed efforts for fundamental research and non-fundamental research. Some proposed research may present a high likelihood of disclosing performance characteristics of military systems or manufacturing technologies unique and critical to defense. Based on the anticipated type of proposer (e.g., university or industry) and the nature of the solicited work, the Government expects some awards will include restrictions on the resultant research requiring the awardee seek DARPA permission before publishing any information or results relative to the program. For additional information on fundamental research, please visit Proposer Instructions: General Terms and Conditions.

- Proposers should indicate in their proposal whether they believe the scope of the research included in their proposal is fundamental or not. While proposers should clearly explain the intended results of their research, the Government shall have sole discretion to determine whether the proposed research shall be considered fundamental and to select the award instrument type. Appropriate language will be included in resultant awards for non-fundamental research to prescribe publication requirements and other restrictions, as appropriate. This language can be found at Proposer Instructions: General Terms and Conditions.

- For certain research projects, it may be possible that although the research to be performed by a potential awardee is non-fundamental research, their proposed subawardee's effort may be fundamental research. It is also possible the research performed by a potential awardee is fundamental research while their proposed subawardee's effort may be non-fundamental research. In all cases, it is the potential awardee's responsibility to explain in their proposal which proposed efforts are fundamental research and why the proposed efforts should be considered fundamental research.

- DARPA's Fundamental Research Risk-Based Security Review Process (formerly CFIP, now FRR-BS "aka FERBS") is an adaptive risk management security program designed to help protect the critical technology and performer intellectual property associated with DARPA's research projects by identifying the possible vectors of undue foreign influence. DARPA will create risk assessments of all proposed senior/key personnel selected for negotiation of a fundamental research cooperative agreement award. The DARPA risk assessment process will be conducted separately from the DARPA scientific review process and adjudicated prior to final award. For additional information on this process, please visit Proposer Instructions: Grants/Cooperative Agreements.

- The APEX Accelerators program, formerly known as the Procurement Technical Assistance Program (PTAP), focuses on building a strong, sustainable, and resilient U.S. supply chains by assisting a wide range of businesses that pursue and perform under contracts with the DoD, other federal agencies, state and local governments and with government prime contractors. See https://www.apexaccelerators.us/ for more information.

  APEX Accelerators helps businesses:

  - Complete registration with a wide range of databases necessary for them to participate in the government marketplace (e.g., SAM).
  - Identify which agencies and offices may need their products or services and how connect with buying agencies and offices.
  - Determine whether they are ready for government opportunities and how to position themselves to succeed.
  - Navigate solicitations and potential funding opportunities.
  - Receive notifications of government contract opportunities on a regular basis.
  - Network with buying officers, prime contractors, and other businesses.
  - Resolve performance issues and prepare for audit, only if the service is needed, after receiving an award.

- Project Spectrum is a nonprofit effort funded by the DoD Office of Small Business Programs to help educate the Defense Industrial Base (DIB) on compliance. Project Spectrum is vendor-neutral and available to assist businesses with their cybersecurity and compliance needs. Their mission is to improve cybersecurity readiness, resilience, and compliance for small/medium-sized businesses and the federal manufacturing supply chain. Project Spectrum events and programs will enhance awareness of cybersecurity threats within the manufacturing, research and development, as well as knowledge-based services sectors of the industrial base. Project Spectrum will leverage strategic partnerships within and outside of the DoD to accelerate the overall cybersecurity compliance of the DIB.

  www.Projectspectrum.io is a web portal that will provide resources such as individualized dashboards, a marketplace, and Pilot Program to help accelerate cybersecurity compliance.

- DARPAConnect offers free resources to potential performers to help them navigate DARPA, including “Understanding DARPA Award Vehicles and Solicitations,” “Making the Most of Proposers Days,” and “Tips for DARPA Proposal Success.” Join DARPAConnect at www.DARPAConnect.us to leverage on-demand learning and networking resources.

- DARPA has streamlined our Broad Agency Announcements and is interested in your feedback on this new format. Please send any comments to DARPAsolicitations@darpa.mil.