Program Solicitation

Heterogeneous Architectures for Quantum (HARQ)

Microsystems Technology Office

DARPA-PS-25-31
August 7, 2025

OVERVIEW INFORMATION:

- **Federal Agency Name:** Defense Advanced Research Projects Agency (DARPA), Microsystems Technology Office (MTO)
- **Funding Opportunity Title:** Heterogeneous Architectures for Quantum (HARQ)
- **Solicitation Type:** Initial solicitation
- **Funding Opportunity Number:** DARPA-PS-25-31
- **Assistance Listing Number:** Not applicable
- **Dates/Time: All Times are Eastern Time Zone (ET)**
  - Posting Date: August 7, 2025
  - Proposers Day: August 8, 2025
  - Proposal Abstract Due Date: August 28, 2025, at 1:00 p.m.
  - Abstract Virtual Q&A Dates: September 4–17, 2025
  - Notification of Intent to Propose: October 1, 2025, at 5:00 p.m.
  - Question Submittal Closed: October 1, 2025, at 5:00 p.m.
  - Proposal Due Date: October 14, 2025, at 4:00 p.m.
  - Virtual Oral Presentation Dates: October 22 – November 4, 2025
  - Estimated Period of Performance Start: February 1, 2026
- **Anticipated Individual Awards:** Multiple awards are anticipated, with each award valued at up to $2,000,000 for Phase 1, and up to $650,000 for the potential a Scale-Up Period.
- **Types of Instruments That May Be Awarded:** Other Transaction (OT) for Prototype Agreements under 10 U.S.C. 4022
- **NAICS Code:** 541715
- **Agency Contact:**

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Program Solicitation
DARPA-PS-25-31

Heterogeneous Architectures for Quantum (HARQ)
Defense Advanced Research Projects Agency (DARPA)
Microsystems Technology Office (MTO)

Section I: Funding Opportunity Description

The Defense Advanced Research Projects Agency (DARPA) is soliciting proposals towards the realization of heterogeneous quantum computing architectures. Proposed research should investigate innovative approaches that enable revolutionary advances in theory, devices, and system concepts for quantum interconnects, quantum circuit compilers, distributed algorithms, resource estimation, quantum memory/repeater devices, quantum frequency converters, microwave-to-optical transducers, and other elements at the intersection of hardware and software in the quantum computing stack. Specifically excluded is research that primarily results in evolutionary improvements to the existing state of practice.

A. Introduction

Large-scale quantum computers (QC) have long been lauded as a revolutionary capability, drawing considerable commercial attention and investment in recent years. While the race to build a high-performance QC is crowded with companies pursuing distinct approaches and platforms, there is a common theme: present-day roadmaps focus on homogeneous architectures where the entire system is designed around a single qubit species. This homogeneity is a stark contrast to the heterogeneity of classical information systems, where diverse materials and integration platforms have been highly specialized for optimal performance across different functionalities for processing, memory, and communication. The power of modern-day systems in varied exemplars—such as supercomputers, smartphones, and radars—directly trace to the ability to select the best performing components for every function and to quickly and efficiently move data between them in both hardware and software.

Many qubit species excel at select processing, memory, and communication functions thanks to intensive development over the past two decades. However, the fragility of quantum information has, so far, prevented the efficient interconnection of diverse qubits. Since no known qubit excels at all compute functions, roadmaps for large-scale QCs tend to make up for qubit deficiencies at scale, resulting in exceedingly high infrastructure costs and/or application runtimes for systems capable of executing quantum algorithms with high economic and scientific value. Indeed, the fragility of quantum information imposes severe bottlenecks for prevailing modular architectures for distributed QC.

While the inability to practically combine disparate qubits has precluded serious consideration of heterogeneous QCs, recent material and device advances are laying a new foundation for constructing heterogeneous quantum interconnects. Moreover, theoretical efforts have recently established that communication-intensive architectures can provide substantial reductions in resources and runtime by compiling quantum circuits into distinct zones dedicated to specific functions (e.g., processing, memory, and communication). Collectively, these breakthroughs signal that heterogeneous architectures are feasible and offer superior performance compared to homogeneous architectures by enabling algorithms to run more efficiently while requiring less infrastructure and time to execute applications.

B. Program Description

The principal objective of Heterogeneous Architectures for Quantum (HARQ) is to establish a new heterogeneous QC paradigm that eliminates the constraints of homogeneous, single-qubit platforms. Though present-day homogeneous QC commercial roadmaps assert a trajectory towards high-value applications, the scaling limitations faced by these homogeneous architectures are poised to limit the ultimate size and computational power of these complex systems. The freedom to use optimal qubits for assorted computational functions could unlock scalability to out-of-reach applications in materials discovery, chemistry simulation, and biological modeling with transformative impact to industry, society, and national security.

HARQ will assess the plausibility of heterogeneous architectures and test whether they are inherently more scalable than homogeneous architectures through a concerted, multi-thrust effort centralized at the hardware/software intersection, as illustrated in the stack representation of Figure 1. In the envisioned architecture, a QC module will host tens to hundreds of physical qubits of the same species—e.g., neutral atoms. This module will then be interconnected with other QC modules containing different qubits—e.g., transmons—through tens- to hundreds-of-meter-long physical communication channels in a data-center-like environment. Such a QC is heterogeneous at the multi-module-system level, and the program will not explore interactions of different qubit species within the same module. The program technical areas will develop the heterogeneous circuit design concepts necessary to distribute operations and provide the component-level innovations necessary to transfer information between independent nodes of a heterogeneous multi-module system.

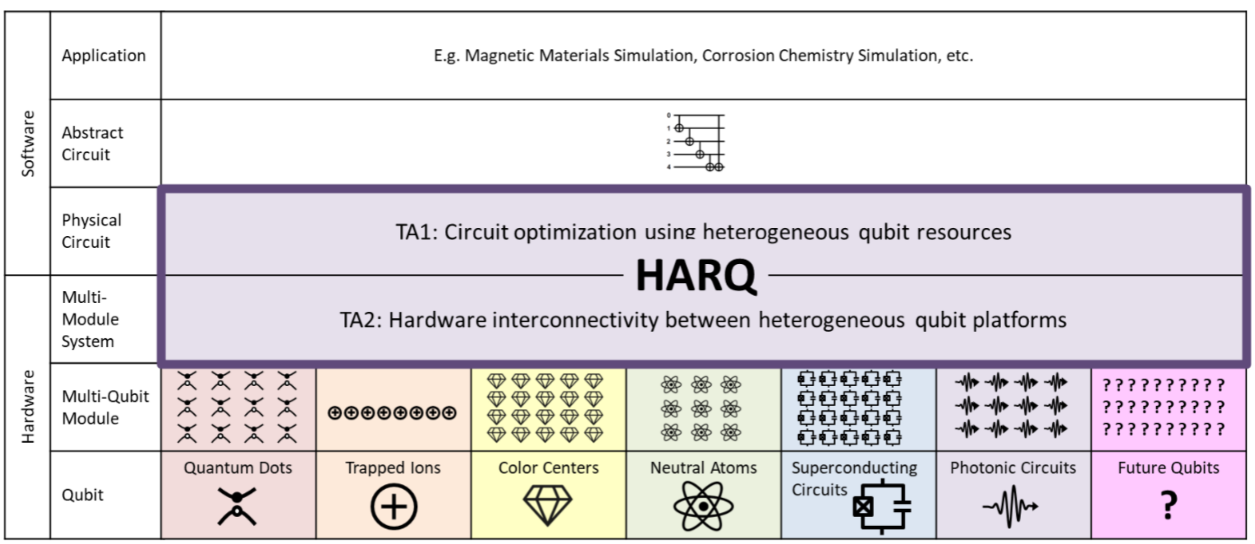

Figure 1. Representative heterogeneous QC hardware/software stack. HARQ's effort to establish the viability of heterogeneous QC technology and systems is focused on the hardware/software intersection and will consider elements across the full quantum computing stack, including quantum error correction codes (not shown), to compile abstract circuits into physical circuits, and to enable system connectivity between multi-qubit modules and multi-module systems.

C. Program Structure

HARQ includes a 24-month single (Phase 1) period composed of two Technical Areas (TAs). **Proposers may address multiple TAs but must submit separate abstracts and proposals for each TA. Additionally, multiple TA2 abstracts and proposals are possible.** Individual project budgets for the Phase 1 period are capped at $2,000,000. An additional Phase 1 9-month Scale-Up Period capped at $650,000 must be included in the proposals. The Scale-Up Period is not guaranteed and may be authorized by the Government through a modification.

While individual projects within the TAs will pursue their own research scope, DARPA expects all HARQ performers to participate in intensive, workshop-style technical interchange meetings (TIMs) with other performers and a collection of Government Team organizations to develop hardware/software co-design principles for heterogeneous QC. These TIMs will occur quarterly and at specific milestones illustrated in Figure 2. Findings from the TIMs will be incorporated into a heterogeneous QC architecture study led by the Government Team. As the architecture specifications advance, the Government Team will periodically guide the design goals and demonstration priorities of TA1 and TA2 projects. The Government Team will provide reference qubit parameters and benchmark circuits to TA1 and TA2, as well as conduct independent verification and validation (IV&V) and test and evaluation (T&E) on performer deliverables. More details on the scope and goals of the HARQ Government Team activity can be found in DARPA-SN-25-99. Proposers to the HARQ PS are not required to address details of the Government Team activity but should ensure that their proposals include adequate personnel and resources to support TIM participation.

Information sharing between TA1 and TA2 performers is critical for the HARQ program's success. Therefore, it is required that all TA1 and TA2 teams execute Associate Performer Agreements (APAs) within 30 days after award.

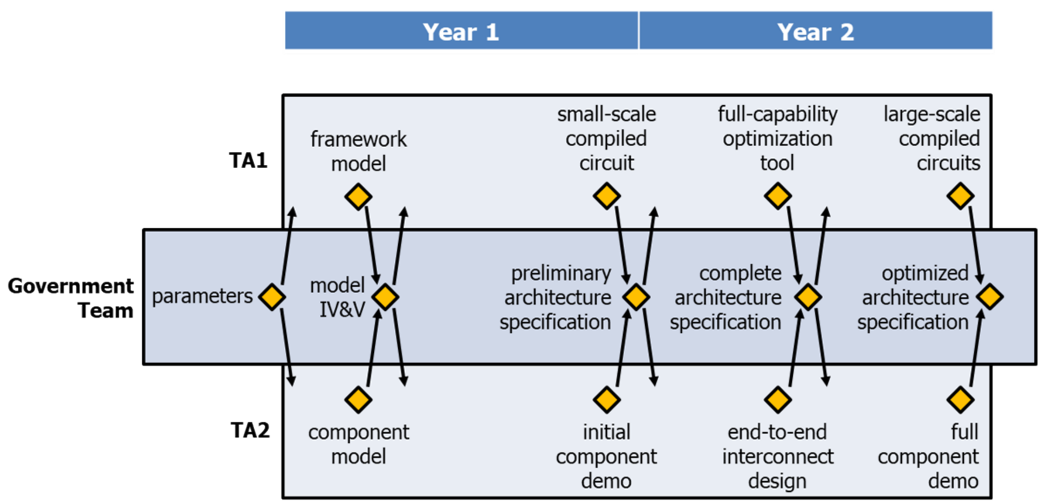

Figure 2. Program schedule showing technical interchange at program milestones. Quarterly technical interchange meetings (TIMs) are not shown in the graphic. For more contextual information involving the Government team's role, see the request for information for Government support in DARPA-SN-25-99.

TA1: Multi-qubit Optimized Software Architecture through Interconnected Compilation (MOSAIC)

Technical Area 1 (TA1) will drive theory, modeling, simulation, and software development efforts to develop heterogeneous quantum circuit compilers that optimize resource allocations between diverse qubit species. DARPA envisions that the ability to generate such "mosaics" of physical circuit layouts will provide the software basis to combine diverse quantum computer modules in future data-center-scale systems. TA1 seeks to determine the resource efficiency advantage that heterogeneous circuits offer to the execution of QC applications, as measured by the number of physical qubits, number of operations, runtime, and/or other parameters that impose monetary cost to build and run a large-scale QC. The target resource efficiency advantage is a factor of 1,000 lower than homogeneous architectures, as shown in Table 1.

Table 1. TA1 Metrics

Parameter	Compiler Metric
Resources	1,000x lower than homogeneous compilations[*]
Circuit Size	1,000 logical qubits[†]

DARPA acknowledges that no existing quantum circuit compiler methods can demonstrate TA1 metrics and seeks new frameworks that use physical, logical, and circuit parameters of diverse qubit species to optimally assign them to QC functions. Such parameters may include coherence time, clock speed, code rates, inter-qubit coherence, inter-qubit connectivity, and/or other qubit features that differentiate their relative strengths in executing various steps of an abstract circuit through the quantum error correction layer down to the physical layer. Representative qubit parameters will be provided by the Government Team to TA1 performers to establish a uniform basis for optimization frameworks across the program.

While TA1 projects may employ multiple qubit and quantum error correction code properties to optimize physical circuit resources, DARPA also expects that performers will need to develop new techniques to map quantum information between qubit species with varying connectivity, clock speed, and error correction codes. For the purposes of this solicitation, the circuit layout required to accomplish this mapping is defined as an “interface”. It will be crucial for optimization frameworks to account for the penalties that interfaces incur in quantum communication latency, communication and ancilla qubits, classical control, information processing, and readout. Communication between different qubit species will occur only via interconnects. The framework may use both classical and quantum interconnects, but the computational overhead for classical interconnects must also be considered in resource estimation. Relevant hardware details of quantum interconnect solutions, gleaned through technical interchange with TA2 performers and the Government Team, will also be incorporated as it becomes available during the program. Proposals to TA1 must describe the principles and methods to develop such optimization frameworks during the program and explain how proposers expect to support these methods, e.g.,

[*] During the program, performers will calculate resources by plugging the physical circuit output of their compiler tool into an efficiency function provided by the Government Team. This function will assign weights to the number of physical qubits and operations for each qubit species within the circuit. It is expected that the compiler tool will optimize resource allocations through the same function. The resource metric will be demonstrated by comparing the optimal heterogeneous compilation to the homogeneous compilations that the tool produces when constrained to single qubit species.

[†] During Year 1, TA1 compilers will be benchmarked using small, reference logical circuits provided by the Government Team. These circuits are expected to be representative of multiple algorithmic- and application-relevant structures. In Year 2, the performer’s compiler tool must be extended to be capable of compiling circuits containing at least 1,000 logical qubits with a quantum error correction layer.

through theoretical analysis, small-scale density matrix simulation of quantum hardware, or heuristic application of relevant experimental results.

During the program, TA1 efforts must implement optimization frameworks via circuit compiler software tools with built-in resource estimation functionality. These tools must be capable of ingesting general-purpose, abstract quantum circuits. Qubit, error correction, and interconnect parameters must be easily updated within the compiler tool to reflect evolving findings from TA2 and the Government Team. The tool does not need to exercise clock synchronization or other methods of real-time control. While DARPA expects that the primary TA1 activity will be to compile abstract circuits into physical circuits through an intermediate quantum error correction layer, the program is open to concepts that consider heterogeneous optimization at additional levels of the stack, e.g., in the translation from algorithms into physical circuits, implementation of hierarchical quantum microarchitecture, or deeper compiling into quantum machine code. Explicitly out of scope for this effort is any work related to developing new quantum error correction codes, including those purpose-built for heterogeneous systems. As appropriate, proposers may employ machine learning approaches for finding optimal circuit decomposition, partitions, and allocations of qubit resources. While the compiler must be able to run on any abstract circuit, proposers may target to demonstrate resource reduction for certain classes of algorithms or subroutines. Proposers must identify a physical quantum circuit for which they plan to develop and demonstrate their tool.

The accuracy and validity of the compiler tool will be verified by the Government Team. Tools must be delivered with sufficient documentation so that the Government Team can use and modify the tool to independently apply the optimization framework. The Government Team will benchmark the tool on standardized reference circuits.

TA2: Quantum Shared Backbone (QSB)

Technical Area 2 (TA2) will drive hardware efforts to develop heterogeneous quantum interconnect technologies that support communication between different qubit species. DARPA envisions that this "quantum shared backbone" will provide the hardware basis to combine diverse quantum computer modules in future data-center-scale systems. For such heterogeneous systems to reap a scaling advantage compared to homogeneous or even non-modular architectures, the interconnects must operate with high state transfer rates and fidelities that do not excessively penalize the efficiency boosts sought by TA1 or the local operations within each module. To this end TA2 metrics (Table 2) seek interconnect performance on par with the highest two-qubit gate processes achieved across the major qubit platforms under development today.

Table 2. TA2 Metrics

Parameter	Interconnect Metric‡
State Transfer Rate	10 MHz
State Transfer Fidelity	99.9%

DARPA acknowledges that there is no basis for demonstrating heterogeneous interconnects at this performance level using standard teleportation methods and components. Losses, noise, and measurement errors in quantum communication channels impose severe limits on teleportation rates and fidelities. Supplementing such interconnects with the frequency and bandwidth translation components needed to convert between diverse qubits only exacerbates these challenges. HARQ TA2 seeks radical innovation in interconnect components and communication modalities to overcome these limits.

HARQ only solicits TA2 concepts for component-level hardware development and quantum-interconnect-level modeling. TA2 Proposers must respond to one of the following tracks; participation in multiple TA2 tracks is permitted but will require submitting separate abstracts and proposals.

Track A. Quantum memories or repeaters. Memory-enabled quantum interconnect modalities have the potential to boost teleportation success rates in the presence of multiple sources of loss ranging from input/output-coupling, propagation, mode matching, and frequency conversion. As a precursor to attempting such interconnects, this track seeks innovative concepts in components with addressable qubit storage capabilities, sometimes referred to as quantum memories or repeaters. Proposals for this track must target advanced functionality, such as long storage time, high read/write rate and fidelity, large number of memory qubits, and ability to run operations between memory qubits to enable distillation and/or other methods of increasing state transfer fidelity. To demonstrate applicability to arbitrary combinations of interconnected end-node qubit species, proposers to this track must disclose the input/output frequency and bandwidth requirements of the memory and describe the demands that these place on supplementary conversion components.

Track B. Optical-to-optical frequency converters or entangled photon sources. Future heterogeneous QC systems may incorporate end-node qubits with widely varying operation frequencies, and the optimal communication band for interconnection is yet to be determined. To spur the broadest range of qubit and communication frequency options, this track seeks component concepts that enable translating quantum states across the ultraviolet-A (UVA) through near-infrared (NIR) spectrum. As interconnects employing such techniques could operate with end-

‡ Interconnect metrics are to be met between a single physical end-node qubit in module A and a single physical end-node qubit in module B, for any pairwise combination of end-node qubit species A and B. The interconnect may host additional resources, for example, memory qubits, distillation protocols, etc. DARPA recognizes that most qubits do not operate at the level of TA2 metrics. As such, interconnect metrics do not include the response time and infidelity of end-node qubit processes. Proposers should assume an interconnect distance of 10 meters to calculate time-of-flight latency.

node qubits in either emissive or absorptive mode, frequency converters and nondegenerate entangled photon sources (EPS) are both relevant to this track. Converter proposals must target advanced functionality, such as high single-photon conversion efficiency, low noise, high input/output coupling efficiency, and low pumping power requirements. EPS proposals must target similar features as well as high brightness, high coincidence rate, and low accidental rate. Proposals may target a specific pair of input/output wavelengths to describe their approach. A single design does not need to simultaneously operate across the full spectrum; rather, to demonstrate applicability to arbitrary combinations of interconnected end-node qubit species, proposals must describe how the approach can be extended during the program and without excessive re-development to arbitrary wavelengths in the UVA through NIR spectrum. Concepts that enable emerging qubit optical frequencies beyond the UVA-NIR spectrum are also of interest but not required. DARPA and the Government Team will periodically update input/output wavelength priorities for experimental demonstration during the program.

Track C. Microwave-to-optical transducers. Converting single microwave photons to and from optical photons presents a long-standing challenge to prospects of combining prominent qualities of superconducting qubits for processing and optical qubits for communication. This track seeks innovative component concepts that exceed the limits imposed by the weak coupling methods between microwave and optical domains. Proposal for this component must target advanced functionality, such as high single-photon conversion efficiency, low noise, high repetition rate, and bi-directional operation or other methods to convert optical photons both to and from microwave photons at superconducting qubit frequencies in the 4–8 GHz range. Proposals may target a specific pair of optical and microwave frequencies to describe their approach. A single design does not need to simultaneously operate across the full spectrum; rather, to demonstrate applicability to arbitrary combinations of interconnected end-node qubit species, proposals should describe how the approach can be extended during the program and without excessive re-development to arbitrary microwave frequencies in the 4–8 GHz range. Concepts that enable emerging microwave qubit frequencies beyond 4–8 GHz are also of interest but not required.

Track D. Alternative components and/or interconnects. Concepts that do not fall under Tracks A–C, but still provide a path to TA2 goals, may be proposed to Track D. While the scope of projects in Tracks A–C will consist of single-component hardware development, Track D may include multiple components and/or end-to-end interconnect development if appropriate for the proposed concept. End-to-end interconnect proposals may propose additional performance figures of merit if the physical state transfer model assumed by Table 2 does not apply, but if so must provide a rationale for how the figures of merit provide a matching capability to TA2 metrics. Additionally, all Track D proposals must describe how the concept enables heterogeneous architectures.

Technologies of interest for TA2 hardware efforts include but are not limited to: color center and quantum dot photonic integrated circuits (Track A), atomic-photonic integration (Track A), multi-stage second- and third-order nonlinear optical devices (Track B), multi-stage transduction (Track C), qubit-mediated frequency conversion and transduction (Tracks B and C), high-dimensional photonic states for error-corrected communication (Track D), and novel fiber or free-space optical componentry for qubit-interfacing interconnects (Track D). Proposals to all Tracks must support heterogeneous interconnect modalities, i.e., concepts that only provide interconnectivity between modules of the same qubit species are not of interest.

Proposals must define component-level metrics that enable meeting the goals and metrics of TA2 when incorporated into an end-to-end quantum interconnect model. For DARPA to assess the technical innovation and risk offered by component concepts, proposers must disclose a baseline performance specification that can be rigorously substantiated through analysis of the proposed design. The target specification may exceed the baseline by estimating the theoretically achievable performance, if all proposed innovations succeed. Proposer-defined component metrics may be demonstrated using emulated signals, e.g., single-photon sources, rather than actual qubits at the input and output.

For the purposes of this solicitation, a quantum interconnect is defined as an assembly of hardware components capable of running a sequence to transfer the quantum state of one physical qubit to a remote physical qubit separated by ten or more meters. An illustrative example of an interconnect is shown in Figure 3. Interconnect models should describe the role of the proposed component and identify any additional componentry (e.g., from other TA2 tracks) required to run such a sequence. Baseline interconnect model specifications may assume state-of-the-art performance for these other components, while target interconnect model specifications may involve novel functionality or performance beyond state of the art. These and other assumptions of the interconnect model should be made clear in the full proposal. The interconnect model included in the proposal will serve as a starting point for additional refinement during the program based on technical interchange between other projects in TA1 and TA2 as well as the Government Team.

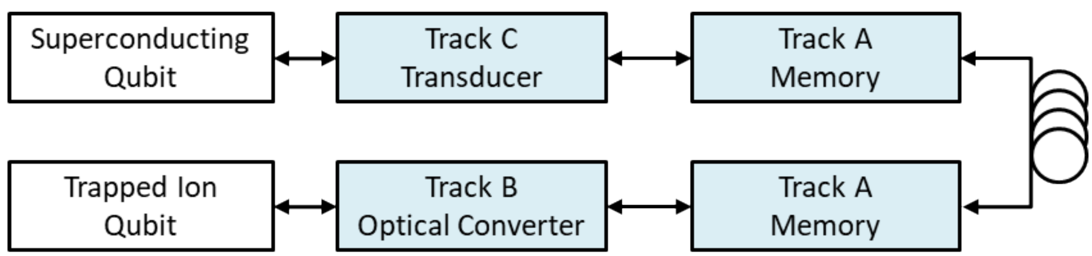

Figure 3. Schematic of a notional memory-enabled, teleportation-based, quantum interconnect scheme connecting different qubit modalities at the end nodes (white boxes) via a combination of HARQ components (blue boxes). The schematic is for illustrative purposes only, and proposers are not required to adhere to this interconnect modality.

The appropriate scope of hardware development efforts to demonstrate a path to TA2 metrics and goals will depend on the proposed concepts and are likely to vary significantly across Tracks A–D. Proposals should provide clear traceability between the set of proposed measurements and experiments to quantitatively substantiate the proposer-defined component metrics. DARPA plans to use the proposal abstract process to provide feedback on the appropriate scope of projects submitted to TA2.

<u>TA1 and TA2 Scale-Up Period</u>

All TA1 and TA2 proposals must include a 9-month Scale-Up Period for hardware/software co-design work towards an end-to-end interconnect demonstration, which would be the focus of the potential Expanded Program Follow-On Tasking (EPFT) described below. Specifically, the Scale-Up Period task would be as follows:

> *Finalize an end-to-end interconnect model, teaming arrangement, commercialization plan, and test plan at the CUI level, which combines multiple*

> *components from TA1 projects, interface methods from TA2 projects, and/or innovations from outside the HARQ program.*

Based on technical results achieved as early as month 12 of Phase 1, DARPA may pursue exercise of one or more performers' Scale-Up Periods. If pursued, performers should expect that the 9-month Scale-Up Period would be executed in parallel to the remaining Phase 1 tasks. Exercise of the Scale-Up Period will be subject to technical achievements and the availability of funds, and therefore only a subset of HARQ performers may have their Scale-Up Periods exercised.

<u>TA1 and TA2 Expanded Program Follow-On Tasking (EPFT)</u>
Separate from the 24-month Phase 1 and 9-month Scale-Up Period, DARPA may, at its sole discretion, negotiate and incorporate EPFT with a period of performance ranging from twelve (12) to twenty-four (24) months.

EPFT may include significantly expanded scope, integration of new tasks, or broader implementation of capabilities demonstrated under the Base Effort.

EPFT will only be incorporated through mutual agreement and a modification to the Agreement establishing its scope, milestones, and funding. The decision to incorporate EPFT will be based on the technical results of Phase 1, Scale-Up Period, mission priorities, and availability of funds.

The EPFT is not included in the HARQ PS and therefore proposals shall not address it.

D. Schedule, Milestones, and Deliverables

For planning and budgetary purposes, proposers should assume a program start date of February 1, 2026.

<u>Schedule</u>

A summary of the program schedule is presented above in Figure 2.

<u>Milestones</u>

The HARQ milestones are listed below for each technical area.

Table 3. TA1 Milestones

Milestone		Month	Exit Criteria/Deliverable	Payment*
1	Initial Optimization Framework and Kickoff	1	• Kickoff presentation slides • Documentation of initial optimization framework in Government-specified format • Executed APAs with all other TA1 and TA2 performers	$50,000

2	Initial Interface Layout	3	• Interface circuit layout for one combination of Government-defined qubit parameters • Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary optimization framework details for architecture development	$200,000
3	Framework Revision	6	• Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary optimization framework details for architecture development • Summary of findings from coordination with TA2 and Government Team at in-person TIM	$275,000
4	Intermediate Interface Layouts	9	• Interface circuit layout for all combinations of Government-defined qubit parameters • Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary optimization framework details for architecture development	$200,000
5	Small-Circuit Demo	12	• Demonstration of optimization framework on small benchmark circuits • Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary optimization framework details for architecture development • Summary of findings from coordination with TA2 and Government Team at in-person TIM	$275,000
6	Initial Compiler Tool Code	15	• Demonstration of functional compiler tool code • Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary optimization framework details for architecture development	$200,000

7	Version 1 Compiler	18	• Delivery of first version of the compiler tool code to Government team • Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary optimization framework details for architecture development • Summary of findings from coordination with TA2 and Government Team at in-person TIM	$300,000
8	Large-Circuit Demo	21	• Software demonstration of optimization framework on Government-provided large benchmark circuit • Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary optimization framework details for architecture development	$200,000
9	Optimized Circuit and Resource Estimate	24	• Optimization results and detailed resource estimate for Government-provided large benchmark circuit • Delivery of updated version of the compiler tool code to Government team • Revision of optimization framework based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary optimization framework details for architecture development • Prototype Delivery: proof-of-concept software tool and a proof-of-concept model • Final Report (End of Phase Report)	$300,000

** Payments listed for each milestone are not-to-exceed amounts.*

Table 3. TA2 Milestones

Milestone		**Month**	**Exit Criteria/Deliverable**	**Payment***
1	Initial Designs and Kickoff	1	• Kickoff presentation slides • Documentation of initial component-level and interconnect-level designs in Government-specified format • Orders-placed for long-lead purchase items • Executed APAs with all other TA1 and TA2 performers	$250,000

2	Design Revision 1	3	• Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary component details for architecture development	$175,000
3	Initial Interconnect Models	6	• Interconnect designs for all combinations of Government-defined qubit parameters • Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary component details for architecture development • Summary of findings from coordination with TA1, other TA2 tracks, and Government Team at in-person TIM	$200,000
4	Draft Interface Control Document	9	• Draft interface control document • Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary component details for architecture development	$175,000
5	Initial Testing	12	• Experimental test results demonstrating underlying component features • Detailed analysis of interconnect-level performance and outlook based on underlying component feature performance • Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary component details for architecture development • Summary of findings from coordination with TA1, other TA2 tracks, and Government Team at in-person TIM	$200,000
6	Design Revision 2	15	• Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary component details for architecture development	$200,000

7	Final Interface Control Document	18	• Final interface control document • Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary component details for architecture development • Summary of findings from coordination with TA1, other TA2 tracks, and Government Team at in-person TIM	$300,000
8	Design Revision 3	21	• Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at virtual TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at virtual TIM that updates a program-wide audience on the necessary component details for architecture development	$200,000
9	Full-Function Testing	24	• Experimental demonstration of full component functionality • Optimized interconnect designs, and detailed analysis of interconnect performance and future outlook • Delivery of functional component to Government team • Revision of component design based on Government feedback and delivery of revised documentation • Presentation delivered at in-person TIM that updates Government Team on detailed technical R&D progress • Presentation delivered at in-person TIM that updates a program-wide audience on the necessary component details for architecture development • Prototype Delivery: physical proof-of-concept device. • Final Report (End of Phase Report)	$300,000

** Payments listed for each milestone are not-to-exceed amounts.*

Table 4. Scale Up Period Milestones

Milestone		Month	Exit Criteria/Deliverable	Payment*
1	Team Integration	3	• Establish an optimized team composition required for end-to-end interconnect demonstration concepts	$150,000
2	CUI Compliance Readiness	6	• Establish CUI-compliant systems and processes	$200,000
3	EPFT Plan	9	• Develop a test plan for an end-to-end interconnect demonstration • Develop a Task Description Document and Cost Proposal for an end-to-end interconnect demonstration • Develop an initial commercialization plan for HARQ technology	$300,000

** Payments listed for each milestone are not-to-exceed amounts*

Deliverables

TA1 and TA2 performers will be expected to provide, at a minimum, the following deliverables:

- Technical presentations as defined in the milestone table and in support of semi-annual in-person Principal Investigator (PI) meetings to report on technical progress utilizing a Government-provided template
- Technical reports as defined in the milestone table
- Final report summarizing the completed research, to include the following:
  - Description of the technical developments and achievements toward the metrics
  - Tables and explanations of how experiment results meet or exceed program metrics
  - Plans and projections for the subsequent phase with an updated risk assessment in each of the critical program areas
- (TA1 only) Delivery of at least two versions of the compiler code to the Government with adequate documentation for use and modification of the tool
- (TA2 only) Delivery of a minimum of one complete and functional final TA2 component prototype to the Government.
- (Scale-Up only) Delivery of a Task Description Document, Cost Proposal, and test plan for an end-to-end interconnect demonstration.

<u>Relevant Dates and Travel</u>

All proposals must include the following meetings and travel in the proposed schedule and costs:

- To foster collaboration between teams and disseminate program developments, a two-day TIM will be held approximately every six months, with locations split between the East and West Coasts of the United States. Additional Principal Investigator (PI) meetings will be scheduled by DARPA for program management purposes. For budgeting purposes, plan for six (6) two-day meetings over the course of 24 months: three (3) meetings in the Washington, D.C., area and three (3) meetings in the San Francisco, CA, area. Virtual meetings will be held during intervening quarters between the semi-annual in-person meetings.
- Proposers should also anticipate at least one site visit per phase by the DARPA Program Manager during which they will have the opportunity to demonstrate progress towards agreed-upon milestones.

E. Government Furnished Equipment/Property/Information (GFE/GFP/GFI)

The Government Support (GS) team will provide the following information and support for the performers:

Table 5. HARQ GFE/GFP/GFI

Item		Month	GFI
1	Parameters	1	• Representative parameters of qubit hardware, error correction codes, and interface parameters to guide TA1 and TA2 development
2	TA1 Optimization Function	1	• Formula to convert resources calculated by TA1 compiler into efficiency figure of merit
3	Small Benchmark Circuits	3	• Representative small (<10 logical qubits) benchmark circuits to run TA1 framework

4	Large Benchmark Circuit	12	• Representative large (>1,000 logical qubits) benchmark circuit to run TA1 framework
5	Architectural Specifications	TBD	• System co-design information will be provided up to quarterly to guide TA1 and TA2 redesigns

F. Intellectual Property

The Government will require no less than Government Purpose Rights (GPR) to intellectual property (IP) developed under the program. For IP development prior to the start of the agreement that will be utilized during program activities and delivered to the Government, proposers should clearly identify the IP, the Deliverable associated with the IP, and the anticipated level of IP rights that will be given to the Government. Proposers must also identify any items that would prohibit GPR, including but not limited to anticipated license restrictions, patents, etc.

As the efforts progress, it is expected that performers will provide regular updates to the Government regarding any changes to the overall IP posture that specifically deviate from GPR, additions to previously asserted or defined rights due to technological development, and any anticipated challenges to GPR. For the purposes of this Program Solicitation, the following definitions apply:

- **"Data"** refers to recorded information, regardless of form or method of recording, which includes but is not limited to, technical data, software, mask works and trade secrets. The term does not include financial, administrative, cost, pricing, or management information and does not include inventions.
- **"Government Purpose"** means any activity in which the United States Government is a party, including cooperative agreements with international or multi-national defense organizations, or sales or transfers by the United States Government to foreign governments or international organizations. Government purposes do not include the right to use, modify, reproduce, release, perform, display, or disclose technical data for commercial purposes or authorize others to do so.
- **"Government Purpose Rights"** means the rights to use, duplicate, or disclose Data, in whole or in part and in any manner, for Government Purposes only, and to have or permit others to do so for Government Purposes only.

G. Acquisition Strategy

The Government's acquisition strategy for HARQ is structured to minimize the administrative burden of entry and reduce program risk. To facilitate this objective, the Government will use the following acquisition process:

1. **Proposers Day.** DARPA will hold a virtual webcast on August 8, 2025, from 11:00 a.m. to 4:00 p.m. ET to introduce the science and technology community (industry, academia, and Government) to the HARQ program's vision and goals, to collect questions that the Government may answer during the Question-and-Answer (Q&A) session, and to facilitate potential teaming. Attendance at this event is optional.
2. **Questions and Answers.** DARPA will post a consolidated Q&A document on a regular basis. To access the posting go to: http://www.darpa.mil/work-with-us/opportunities. Under the DARPA-PS-25-31 summary will be a link to the Q&A document. Submit your question(s) by email to HARQ@darpa.mil. In order to receive a response sufficiently in advance of the Proposal due date, send your question(s) on or before the due date and time as stated in the Overview section.

3. **Abstracts with virtual Q&A meeting. Abstracts are required to submit a full proposal.** Abstracts are due no later than the due date and time stated in the Overview section. There will be a 30-minute virtual Q&A meeting scheduled with each proposer following receipt of an abstract. The virtual Q&A meetings will be held during the time window specified in the Overview section via DARPA Microsoft Teams. During the Q&A meeting, the Government will ask the proposer's clarifying questions about their abstract. Required abstract content is described in **Attachments A and B** (see Section III for abstract submission guidance).

4. **Abstract Response Letters.** DARPA will respond to all abstracts with a statement as to whether DARPA: (1) Recommends the proposer submit a full proposal or, (2) Does not recommend the proposer submit a full proposal with a rationale for this decision. Regardless of DARPA's response to an abstract, proposers may submit a full proposal.

5. **Notification of Intent to Propose.** Proposers must provide a notification of their intent to propose no later than the due date and time stated in the Overview section, to aid in scheduling Proposal Oral Presentations. Submit your notification by email to HARQ@darpa.mil.

6. **Proposals with virtual Oral Presentation.** Proposals and Oral Presentation slides are due no later than the due date and time stated in the Overview section. There will be 45-minute virtual Oral Presentations with 45-minute Q&A sessions scheduled for each conforming full proposal following receipt. The virtual Oral Presentations will be held during the time window specified in the Overview section. Required proposal content is described in **Attachments C, D, and E** (see Section III for proposal submission guidance).
7. **Other Transaction (OT) Agreement Negotiation.** DARPA will review Proposals and Oral Presentations to determine which proposed solutions sufficiently meet the evaluation criteria stated in Section II. After the Oral Presentations, the Government will select proposers to enter negotiations for an OT for Prototype agreement under 10 U.S.C. § 4022. The negotiation phase will include both technical and contractual negotiations to determine the effort that provides the most advantageous solutions for both DARPA and individual proposer teams.

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 Budget.
    - **Overall Scientific and Technical Merit**: The proposed technical approach is innovative, feasible, achievable, and complete. The proposed technical team has the expertise and experience to accomplish the proposed tasks. Task descriptions and associated technical elements provided are complete and in a logical sequence with all proposed deliverables clearly defined such that a final outcome that achieves the goal can be expected as a result of award. 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.
    - **Budget:** The proposed solution is realistic and affordable. The budget is realistic and accurately reflects the technical goals and objectives of the solicitation and reflects a sufficient understanding of the level of effort and staffing needed to successfully accomplish the proposed technical approach.

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

Section III: Submission Information

A. Other Transaction (OT) for Prototype Agreements

This Program Solicitation (PS) may result in the award of Other Transaction (OT) for Prototype agreements, which can include not only commercially available technologies fueled by commercial or strategic investment, but also concept demonstrations, pilots, and agile development activities that can incrementally improve commercial technologies, existing Government-owned capabilities, and/or concepts for broad defense and/or public application(s). Follow-on production contracts or transactions may also be awarded pursuant to 10 U.S.C. § 4022. The OT agreement will not require cost sharing unless the offeror is a traditional defense contractor who is not working with a non-traditional defense contractor participating in the program to a significant extent.

B. Reference Sites

The following websites are incorporated by reference and contain additional information regarding overall proposer instructions, general terms and conditions, and OT for Prototype agreements.

- **Proposer Instructions and General Terms and Conditions**: Proposer Instructions and General Terms and Conditions
- **OT Agreements**: Proposer Instructions: Other Transactions

C. Abstracts

This solicitation contains an abstract phase with a virtual Question-and-Answer (Q&A) meeting. **Abstracts are required to submit a full proposal.** Abstracts are due no later than the due date and time stated in the Overview section. Additional instructions for abstract submission are contained within **Attachments A and B**.

D. Proposals

Full proposals to include oral presentation slides are due no later than the due date and time stated in the Overview section. **Attachments C, D, E, F, G, H, and I** contain specific instructions and templates and constitute a full proposal submission.

Please visit Proposer Instructions and General Terms and Conditions for specific information regarding submission methods through the Broad Agency Announcement Tool (BAAT).

E. Artificial Intelligence Tools

DARPA is interested in whether, and to what extent, proposers are using artificial intelligence (AI) tools to contribute to Volume 1 of proposals submitted in response to DARPA solicitations. Therefore, proposers must answer the following questions on the cover sheet of Volume 1 of this solicitation:

- Did you use AI tools to assist in preparing this proposal?
- If yes, what tools did you employ?

Any content in Volume 1 that utilizes an AI tool to generate information, assist in technical understanding, or guide technical work should have a citation and a corresponding reference in the Bibliography section of Volume 1. The citation should specify the tool, content, and purpose. For example, "[AI tool] was used to understand existing state of the art in manufacturing."

NOTE – THIS INFORMATION WILL NOT BE USED FOR EVALUATION PURPOSES. Proposals will be evaluated in accordance with the Evaluation Criteria outlined in the solicitation regardless of whether AI tools were employed.

F. PS Attachments

- **Attachment A**: Abstract Summary Slide Template
- **Attachment B**: Abstract Instructions and Template
- **Attachment C**: Proposal Summary Slide Template
- **Attachment D**: Proposal Instructions and Volume I Template (Technical and Management)
- **Attachment E**: Proposal Instructions and Volume II Template (Cost)
- **Attachment F**: Price Development Spreadsheet
- **Attachment G**: Other Transaction Certification Template
- **Attachment H**: Task Description Document (TDD) Template
- **Attachment I**: Schedule of Milestones and Payments
- **(informational) Attachment J**: Model Other Transaction for Prototype
- **(informational) Attachment K**: Associate Performer Agreement (APA)
- **(informational) Attachment L**: DARPA MTO General Controlled Unclassified Information (CUI) Guide signed November 3, 2023

G. Communication Instructions

All technical, contractual, and administrative questions regarding this notice must be emailed to HARQ@darpa.mil. Emails sent directly to the Program Manager or any other address may result in delayed or no response. All questions must be in English and must include the name, email address, and telephone number of a point of contact. DARPA will attempt to answer all questions in a timely manner and post an FAQ list on the DARPA/MTO Opportunities page at (http://www.darpa.mil/work-with-us/opportunities). The list will be updated on an ongoing basis until two weeks prior to the proposal due date.

Section IV: Special Considerations

A. General Information

- This solicitation, stated attachments, and websites incorporated by reference constitute the entire solicitation. In the event of a discrepancy between the solicitation, attachments, or websites, the solicitation shall take precedence.
- This program is subject to **Attachment K: Associate Performer Agreement**.

B. Security

- As of the time of publication of this solicitation, all proposal submissions are anticipated to be **UNCLASSIFIED.**
- Expanded Program Follow-On Tasking (EPFT), if pursued, will require access to, and storing of, Controlled Unclassified Information (CUI).
- This program is subject to **Attachment L: DARPA MTO General Controlled Unclassified Information (CUI) Guide signed November 3, 2023**). 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*.
- **Controlled Unclassified Information (CUI):** For unclassified proposals containing controlled unclassified information (CUI), applicants will ensure personnel and information systems processing CUI security requirements are in place.
- **CUI Proposal Marking:** If an unclassified submission contains CUI or the suspicion of such, as defined by Executive Order 13556 and 32 CFR Part 2002, the information must be appropriately and conspicuously marked CUI in accordance with DoDI 5200.48. Identification of what is CUI about this DARPA program will be detailed in the DARPA MTO General Controlled Unclassified Information Guide (CUIG) and is provided as **Attachment L** to the PS.
- **CUI Submission Requirements:** Unclassified submissions containing CUI may be submitted via DARPA's BAA Website (https://baa.darpa.mil) in accordance with **Section III** of this PS. Proposers submitting proposals involving the pursuit and protection of DARPA information designated as CUI must have, or be able to acquire prior to contract award, an information system authorized to process CUI information IAW NIST SP 800-171 and DoDI 8582.01.

C. Eligibility

- All responsible sources capable of satisfying the Government's needs, including both U.S. and non-U.S. sources, may submit a proposal that shall be considered by DARPA. 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.

- To ensure fair competition across the ecosystem, DARPA prohibits contractors/performers from concurrently providing Systems Engineering Technical Assistance (SETA), Advisory and Assistance Services (A&AS), or similar support services and being a technical performer, unless the DARPA Deputy Director grants a written waiver. DARPA extends this prohibition to University-Affiliated Research Centers (UARCs), Federally Funded Research and Development Centers (FFRDCs), and government laboratories including National Laboratories.

- UARCs, FFRDCs, and government entities (to include National Laboratories) are prohibited from proposing as performers. UARCs, FFRDCs, and government entities interested in this solicitation must contact the Agency Point of Contact (POC) listed in the Overview section to discuss potential participation as part of the government team. Please note that this paragraph supersedes the "Special Eligibility Considerations for Federally Funded Research and Development Centers (FFRDCs) and Government Entities" section found at Proposer Instructions and General Terms and Conditions. More details on the scope and goals of the HARQ Government Team activity can be found in DARPA-SN-25-99.

D. Research Type

- As of the date of publication of this solicitation, the Government expects that 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 that are 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 that some awards will include restrictions on the resultant research that will require the awardee to seek DARPA permission before publishing any information or results relative to the program. For additional information on fundamental research, please visit Proposer Instructions and 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 and 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, its proposed subawardee's effort may be fundamental research. It is also possible that the research performed by a potential awardee is fundamental research while its proposed subawardee's effort may be non-fundamental research. In all cases, it is the potential awardee's responsibility to explain in its proposal which proposed efforts are fundamental research and why the proposed efforts should be considered fundamental research.

  Effective June 30, 2025, the DARPA Fundamental Research Risk-Based Security Review (FRRBS) will be conducted on all fundamental research awards executed through non-FAR-based instruments. FRRBS 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. The DARPA team will create risk assessments of all proposed

Senior/Key Personnel selected for negotiation of a fundamental research award. The DARPA risk assessment process will be conducted separately from the DARPA scientific review process and adjudicated prior to final award. **For any proposal where fundamental research is included, proposers must submit the (1) Common Form for Biographical Sketch, and (2) Common Form for Current and Pending (Other) Support Information form for all covered individuals, in addition to the volumes and required attachments specified elsewhere in this Program Announcement. Both forms are available via the NSF website -** NSPM-33 Implementation Guidance - Division of Institution and Award Support (BFA/DIAS) | NSF - National Science Foundation For more information, please review the DARPA Fundamental Research Risk-Based Security Review Process detailed at Proposer Instructions: Other Transactions | DARPA

E. Additional Information

- 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 https://www.darpaconnect.us to leverage on-demand learning and networking resources.
- DARPA has streamlined our Program Solicitations and is interested in your feedback on this new format. Please send any comments to DARPAsolicitations@darpa.mil.