DARPA-PS-25-31: Heterogeneous Architectures for Quantum (HARQ) Question and Answer (Q&A) Document

Version 2, August 20, 2025

Gray text indicates questions and answers from previous versions
Blue highlighted text indicates new questions and answers for this version

Version 1, August 15, 2025

Question 1: [Classification] Does DARPA expect any classified work under HARQ?

Answer: HARQ will be operated at the unclassified level for all performers.

[Submitting Abstracts/Proposals] I am new to DARPA. Where are the submissions instructions?

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

Proposers using the DARPA Broad Agency Announcement Tool (BAAT) may encounter heavy traffic on the submission deadline date; thus, proposers should start this process as early as possible and submit abstracts or proposal before the due date.

[Eligibility] Who is or isn't eligible to participate as a performer or on the Government Team?

Answer: All responsible sources capable of satisfying the Government Team requirements, including both U.S. and non-U.S. sources, may submit a proposal that shall be considered by DARPA.

Foreign participants/resources may participate to the extent allowed by applicable Security Regulations, Export Control Laws, Non-Disclosure Agreements, and other governing statutes applicable under the circumstances.

Government Team entities and members cannot be part of both the government team and a R&D performer team.

Generally, the Government Team consists of UARCs, FFRDCs, and government entities (to include national laboratories). Thus, UARCs, FFRDCs, and government entities (to include national laboratories) are prohibited from proposing, in any capacity, as HARQ performers.

Question 2: [Eligibility] Are there any limits to how many proposals that a PI or co-PI may participate in and that are eligible for award?

Answer: No, there are no limits to the number of proposals, tracks, or technical areas on which one PI or co-PI can participate.

Note that each technical area requires a different abstract and proposal submission.

TA2 abstracts and proposals must respond to one of the tracks; participation in multiple tracks is permitted but will require submitting separate abstracts and proposals.

Question 3: [Eligibility] Can multiple proposals, based on similar platforms, be submitted by the same team?

Answer: There is no limit to the number of abstracts and proposals a given team can submit, but separate abstracts and proposals by the same team should have distinct innovative claims and concepts. Each abstract and proposal must provide a complete and independent approach to the TA or track.

Question 4: [Eligibility] Can a proposer include a government lab as a part of their team?

Answer: No. UARCs, FFRDCs, and government entities (including national laboratories) are prohibited from proposing, in any capacity, as HARQ performers.

Question 5: [Eligibility] Can DARPA confirm that any entity participating on the HARQ government team cannot also participate in the program as non-government performers?

Answer: Correct. Government Team entities and members cannot be part of both the government team and a R&D performer team.

Generally, the Government Team consists of UARCs, FFRDCs, and government entities (to include national laboratories). Thus, UARCs, FFRDCs, and government entities (to include national laboratories) are prohibited from proposing, in any capacity, as HARQ performers.

Question 6: [Eligibility] Can DARPA confirm if for-profit corporations are eligible to apply to work with the government team? In the list of who is and is not eligible, companies are not mentioned.

Answer: For-profit corporations may respond to the Government Team RFI, and DARPA will assess their participation on a case-by-case basis. Some tasks of the Government Team that involve dealing with proprietary information of TA1 and TA2 performers may not be appropriate for for-profit entities.

Generally, the Government Team consists of UARCs, FFRDCs, and government entities (to include national laboratories).

Question 7: [Eligibility] Can a not-for-profit research institution propose to HARQ as a performer?

Answer: Yes. DARPA defines "not-for-profit research institutions" as organizations that are not UARCs, FFRDCs, government entities (including national laboratories), or for-profit companies.

Question 8: [Eligibility] Can a not-for-profit research institution propose to HARQ as a performer AND the government team?

Answer: No. Government Team entities and members cannot be part of both the government team and an R&D performer team.

Generally, the Government Team consists of UARCs, FFRDCs, and government entities (to include national laboratories). Thus, UARCs, FFRDCs, and government entities (to include national laboratories) are prohibited from proposing, in any capacity, as HARQ performers.

Question 9: [Eligibility] I have a joint appointment at a national lab and a university. May I propose to HARQ as a performer through my university appointment?

Answer: In this case, the abstract and proposal submitted must be under the University CAGE where you are a PI or co PI.

Question 10: [TA2, Eligibility] Can my TA2 proposal include a government lab as a vendor to supply material?

Answer: This may be acceptable only if such material is generally available to all interested parties and not only to the proposer, and if the arrangement does not involve the government lab providing a key innovation to the concept, providing a unique capability to enable the research project, performing research in any capacity, or advancing the government lab's capabilities to compete in the broader R&D field through the proposed work.

Question 11: [APA, Technical Interchange] How will DARPA negotiate IP protections and technical interchange between performers while maintaining a highly collaborative program?

Answer: All HARQ performers will be required to execute APAs (Associate Performer Agreements) to enable sharing of program-specific information. HARQ Performers will be responsible for protecting their own IP under their established APAs.

Deliverables to the Government will have either Unlimited Rights or Government Purpose Rights (GPR). The proposal template includes sections to describe the information that you envision making available across the program in the Deliverables. Please note any pre-existing proprietary concerns that affect these determinations. This will include clearly identifying Background Technology.

Question 12: [APA, Technical Interchange] What and who will control the non-disclosure and/or teaming agreements during the technical interchange meetings between TA1, TA2, and government team organizations?

Answer: All HARQ performers will be required to execute APAs (Associate Performer Agreements) to enable sharing of program-specific information. HARQ Performers will be responsible for protecting their own IP under their established APAs. HARQ performers will control their own non-disclosure and/or teaming agreements.

Proposers may identify their own process for information sharing with other performers provided they observe the HARQ Associate Performer Agreements (APA).

Before Award, DARPA will provide the required HARQ performers points of contact across the program for information sharing.

As performers develop plans to execute the Scale-Up Period, DARPA expects that teams will self-align through the TIMs. DARPA and the Government Team will advise on coordination and encouragement of teaming.

Question 13: [Technical Interchange] Is there a defined requirement for the portion of a project that is devoted to interacting with the Government team?

Answer: No. Proposers should identify the resources necessary to meet the milestones.

Question 14: [Milestones/Deliverables] If a prospective HARQ performer has shared or provided results to DARPA as part of a different program, can that information be re-delivered in fulfillment of a TA requirement for the HARQ program?

Answer: Yes, provided the information is relevant to HARQ Deliverables, Metrics, Milestones, and goals.

Question 15: [TA1, TA2, Scope] Is it better to focus on a single solution in the proposal or to include another if we have an alternative solution as well?

Answer: Abstracts and proposals must be unique, independent, and focus on a single solution.

Question 16: [TA1] Is the TA1 resource estimation required made in terms of logical qubits or physical qubits?

Answer: Physical.

Question 17: [TA1, Metrics] For abstract/proposal purposes, can we choose an arbitrary weighting function of n_qubits and T for resource estimates? What constraints, if any, are there on this function?

Answer: Yes, proposers are welcome but not required to identify an exemplary weighting function. If included, proposers must justify the rationale for the weighting function. The actual weighting function will be provided by the government during the program.

Question 18: [TA1, Metrics] How fast does the compiler need to run?

Answer: This program does not specifically impose any requirements on the runtime of the compiler. However, the runtime of the compiler may be a factor in the government's assessment of the technical feasibility of the proposal (within the Overall Scientific and Technical Merit evaluation criterion) and impact of the proposed work (within the Potential Contribution and Relevance to the DARPA Mission evaluation criterion).

Question 19: [TA1, Metrics] How will benchmark circuits be chosen?

Answer: Circuits are expected to be representative of multiple algorithms with applications relevant to the DoD. The compiler may be designed to allow optimization for exemplary tasks, however, keeping the software agnostic to the problem class is preferred.

Question 20: [TA1, Metrics] Can DARPA provide an example resource metric?

Answer: Resources will include the number of physical qubits, number of gates and operations, and other physical resource parameters to be defined by the government team during the program.

Question 21: [TA1, Metrics] What if any constraints are there on the size of processors/qubit modalities? What exactly is the I/O of the compiler?

Answer: The government team will provide guidance to all selected performers on the program for constraints and performance measures for given qubit modalities, including the size of processors for each qubit modality. Such factors will be internal parameters of the compiler tool that should be easily revised during the program based on guidance from the government team. The compiler input is an abstract logical circuit of varying sizes, along with information about the error correction schema. The compiler output will be a physical circuit and data describing the physical resources required to execute the circuit. The format on the resource data will depend on the proposer's framework and compiler approach and will be determined by the proposer.

Question 22: [TA1, Deliverables] What does DARPA expect from the final TA1 deliverable, particularly for the "proof-of-concept model"?

Answer: The final TA1 deliverable must provide a framework tool capable of converting a given logical circuit into a heterogeneous physical circuit which optimizes overall resources based upon heterogeneous system parameters.

Question 23: [TA1, Scope] Are classical-quantum hybrid approaches such as circuit cutting allowed.

Answer: Yes. However, as stated in the PS, the computational overhead for classical-quantum interconnects must also be considered in resource estimation.

Question 24: [TA1, Scope] Are specific qubit-modality pairings of interest vs modality-agnostic frameworks? Does DARPA expect MOSAIC software to be agnostic to interconnect architecture and hardware?

Answer: The Program Solicitation (PS) notes the ways that we are seeking to develop generalizability during the program, but specific pairings are welcome as exemplary at the abstract and proposal stage

Question 25: [TA1, Scope] Will TA1 resource functions account for the resource overhead for interface factors such as latency, entanglement distribution protocols, teleportation, photon detection/interference, classical communications overhead, noise mitigation overhead, energy, and multiplexing strategies? How should TA1 proposers account for the large number of these factors with the multitude of different system architectures being explored under the various TA2 tracks?

Answer: DARPA expects that such factors will be considered over the course of the program through Technical Interchange Meetings, and the government team will request revisions to the optimization frameworks depending on the findings across the program. TA1 proposals do not need to include all these factors in the initial framework but should describe how proposers would approach developing them within the program construct.

Question 26: [TA2, Metrics] The TA2 metrics are very hard for microwave-to-optical transduction. Would it be better to have different metrics for microwave-to-optical transduction and optical-to-optical conversion, with microwave-to-optical having, e.g., lower transfer rate metrics?

Answer: The metrics are intentionally hard! Please identify the relevant metrics at the component level to enable the interconnect-level goals of the program. Use the relevant sections of the proposal to identify what baseline specifications are more clearly within reach versus the target specifications, which are inherently riskier.

Question 27: [TA2, Milestones] Does completing TA2 Milestone 9 require successfully demonstrating metrics to complete the milestone and receive payment?

Answer: No. Completing TA2 Milestone 9 requires an experimental test of component functionality. Provide the results of the experimental test to then receive payment.

Question 28: [TA2, Milestones] TA2 Milestone 9 includes "Delivery of functional component to Government team" and "Prototype delivery: physical-proof-of-concept device." Are these two deliverables the same thing repeated twice?

Answer: Milestone 9 includes only one Prototype to be delivered to the Government Team.

Question 29: [TA2, Deliverables] For TA2, do physical deliverables solely include the component, or do they also include supporting hardware?

Answer: Physical deliverables will entail only providing the component. However, DARPA seeks an understanding of the specifications, interfaces, and operation of supporting hardware to enable test and evaluation by the government team.

Question 30: [TA2, Scope] My concept for Track B can work as both a quantum frequency converter and an entangled photon source with the same type of physical device. Should we submit separate abstracts and proposals for each variant or a single proposal with both variants?

Answer: In this case, a single TA2 Track B abstract and proposal covering both variants would be appropriate.

Question 31: [TA2, Scope] We are interested in proposing to multiple TA2 tracks; alternatively, we have a solution that has components that apply to different tracks. Should we combine into one track, or should we submit two proposals to separate tracks?

Answer: Participation in multiple TA2 tracks is permitted but will require submitting separate abstracts and proposals. DARPA suggests submitting two separate abstracts and proposals in this case. If you believe your solution does not lend itself to a neat fit into Tracks A-C, please submit to Track D.

Question 32: [TA2, Scope] Can you specify the specific wavelengths a TA2 optical frequency converter would need to cover?

Answer: There is no requirement regarding the specific wavelengths of a point design. Abstracts and proposals must identify the specific wavelengths they will target for demonstration and describe how their approach can be extended during the program and without excessive redevelopment to arbitrary wavelengths in the ultraviolet-A (UVA) through near infrared (NIR) spectrum.

Question 33: [TA2, Scope] Are heterogeneous N-dimensional qubit (qudit) architectures of interest?

Answer: Hardware components that are capable of supporting transduction between heterogeneous qudit architectures may be considered in TA2, Track D. Such concepts would need to interface with qubit technologies to meet TA2 milestones.

Question 34: [TA2, Scope] Does work replicated in a new material system count as "excessive redevelopment"?

Answer: In this case, the proposer must provide a rationale for how fabrication process changes driven by the switch in materials could be accomplished quickly and efficiently.

Question 35: [TA2, Scope] For TA2, do we need to consider encoding methods when analyzing rate and fidelity?

Answer: No, unless such parameters are relevant to an alternative to state transfer methods to Track D.

Question 36: [TA2, Scope] Is a proposal to improve reliability and reproducibility of integrated photonics at quantum computing relevant wavelength in scope?

Answer: For TA2, any novel approach to develop generalizable componentry for quantum interconnects between heterogeneous systems is in scope. If the proposed effort focuses on improving reliability and reproducibility of existing technologies, but not performance to enable the program metrics, then it is likely not in scope.

Question 37: [TA2, Scope] Can developing interconnected PICs at quantum computing wavelengths fall under TA2 Track D?

Answer: Abstracts and proposals to TA2 must identify a technology development pathway to achieve heterogeneous qubit interconnects and the program metrics identified in the Program Solicitation. On its own, developing interconnects between PICs does not represent a significant advance towards heterogeneous qubit interconnects.

Question 38: [TA2, Scope] Do TA2 proposers need to consider conversion between different qubit encoding formats in addition to frequency translation (e.g., time-bins for photons, polarization for quantum dots)?

Answer: No. Such factors are relevant but not required for TA2 proposals. Proposals to Tracks A, B, or C may address such features if relevant to the proposed component. Components that specifically provide this functionality may be proposed to Track D. Consideration of this type of conversion may be pursued through TIMs.

Question 39: [TA2, Scope] Is DARPA interested in new tech/materials in early stages of development, or only focused on established methods?

Answer: HARQ seeks radical innovation of interconnect components and communication modalities to overcome target metrics, which may require early-stage technologies or less prevalent materials.

Question 40: [TA2, Scope] What does the TA2 "demo principles" effort refer to in the Proposers Day presentation, as opposed to "develop components"?

Answer: The PS provides the specific milestone requirements. "Demo principles" refers to TA2 Milestone 5 which includes "Experimental test results demonstrating underlying component features". The principles and underlying component features will vary widely across TA2 Tracks and proposed approaches, but could include factors such as coherence time of memory qubits, specific noise processes in converter devices, etc. "Develop components" refers to TA2 Milestone 9 which includes "Experimental demonstration of full component functionality". The full component functionality will similarly vary widely across TA2 Tracks and proposed approaches and will entail testing of the proposer-defined component metrics.

Question 41: [TA2, Scope] Do I need to have two species or colors of qubits in my lab to pursue an "end-to-end interconnect" in the Scale-Up Period?

Answer: No. In the event that the Scale-Up Period and EPFT are approved, end-to-end interconnect testing would be performed at a Government Team site that hosts different end-node qubit species. Furthermore, the Scale-Up Period tasking includes design of and end-to-end interconnect and a test plan, not the experimental test itself. The experimental test is envisioned for the EPFT.

Question 42: [TA2, Scope] Is a proposal for an interconnect between two species of the same qubit type (e.g., two different atomic species with meaningfully different computational capabilities, or two different variants of superconducting devices) considered acceptable, or does it need to be an interconnect between entirely different qubit species?

Answer: The former is acceptable as an initial interconnect design at the proposal stage, but the underlying concept should not preclude extension to other qubit species during the program (TA2 Milestone 3). Abstracts and proposals could substantiate this extensibility by providing interconnect models that include additional componentry to convert to different qubit species.

Question 43: [TA2, Scope] How much do components need to be able to do to be in scope?

Answer: The scope of TA2 efforts is expected to vary widely depending on the Track and proposed concepts. Relevant features and capabilities are described in the PS. DARPA intends to provide feedback on the scope of TA2 efforts in abstract responses.

Question 44: [TA2, Scope] I have a concept for a component that would extract entangled photons from a specific qubit species. Is this concept acceptable for TA2?

Answer: On its own, such a concept does not appear acceptable for TA2 since it does not provide interoperability between different qubit species.

Question 45: [TA2, Scope] I have a TA2 component concept that provides similar functionality to a quantum memory but is not a quantum memory. Is this acceptable for Track A?

Answer: Such a concept should be submitted to Track D.

Question 46: [TA2, Scope] I have a concept for microwave-to-optical transducers that connect two separate superconducting processors. Is this within the scope of the program?

Answer: Yes, such transducer concepts are responsive to TA2 track C scope as a component proposal. If proposing an end-to-end interconnect between two superconducting processors, this may be proposed to Track D provided that the concept could be extended to connect with other qubit species, i.e., through additional optical frequency conversion components.

Question 47: [TA2, Scope] My microwave-to-optical transducer concept works for frequencies outside of the 4-8 GHz band. Can I include an additional microwave frequency converter to reach the 4-8 GHz band as a combined solution to Track C?

Answer: Yes.

Version 2 Updates, August 20, 2025

Question 48: [Abstract Submission, Eligibility] In order to submit abstracts, must our company be registered on the SAM platform?

Answer: Proposers may submit an Abstract before they are fully registered on sam.gov. However, proposers *must be fully registered in sam.gov at the time of their proposal submission*. DARPA recommends that you start the process now. It can take up to 5 business days for Sam.gov to create a full profile and CAGE code assuming all the required information is provided. If the required information is missing, you will notice delays in the process. You will need a UEI and CAGE Code in order to be awarded.

Recommended next steps: (a) Visit https://sam.gov/entity-registration, (b) Register, (c) Use a U.S. Bank account (especially non-U.S. proposer organizations), and (d) Once a registration is submitted, follow up with Sam.gov (https://sam.gov/about/contact or 866-606-8220 or live chat at the bottom of https://www.fsd.gov/gsafsd_sp).

Question 49: [Abstract Submission] Before submitting the abstract later this month, when is the last date/time we can contact HARQ for feedback on our technology so that we can align our ideas with DARPA needs or in general understand DARPA needs if we have more questions regarding that?

Answer: There is no separate deadline for questions in advance of abstracts. DARPA will attempt to answer all questions in a timely manner and post a general Q&A document on the HARQ Program page and as an attachment to the solicitation in Sam.gov at (https://www.darpa.mil/research/programs/heterogeneous-architectures-for-quantum). While DARPA will not dictate solutions or provide specific feedback on technical approaches through the Q&A document, the abstract process will include a private Q&A session and response letter including specific feedback on the abstract. Questions may be submitted until October 1, 2025, at 5:00 p.m.

Question 50: [Abstract Submission] Is the Abstract the same as the RFI (DARPA-SN-25-99)? If not, what is the maximum number of pages for the Abstract?

Answer: No, they are not the same. Abstract instructions and template can be found in PS (DARPA-PS-25-31) Attachment B. The maximum number of pages is 8.

Question 51: [Abstract/Proposal Submission] Do we need to involve the government team in the proposal writing stage?

Answer: No, the government team is still being formed, and prospective government team participants should not be involved with abstracts or proposals.

Question 52: [Eligibility] Are non-U.S. universities eligible to act as lead entity for an application?

Answer: Yes, all responsible sources capable of satisfying the Government's needs, including both U.S. and non-U.S. sources, may submit an abstract and proposal that shall be considered by DARPA. 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. Please see the Eligibility section of the DARPA-PS-25-31 for additional information.

Question 53: [Eligibility, Government Team] Can proposers submit an RFI for the government role and an abstract for one of the TAs, provided that they will not be able to submit a full proposal as performers if they are on the Gov team?

Answer: Yes.

Question 54: [Eligibility] If DARPA's intent is that an entity cannot participate on the government team (RFI: DARPA-SN-25-99) and the research team (PS: DARPA-PS-25-31) to avoid conflicts of interest, is DARPA willing to consider an exception to this prohibition in the event an entity proposes an OCI mitigation plan to address OCI concerns?

Answer: DARPA will consider an exception to this prohibition if the government support is restricted to tasks that do not entail receiving performer proprietary information. More specifically, referring to the listed tasks from DARPA-SN-25-99, the permissible activities for the government are:

Task 9: Technoeconomic analysis for heterogeneous quantum computing systems
Task 10: Engagement with the quantum computing industry
Task 11: Technical workshop management for program-wide technical interchange

Question 55: [Eligibility] We understand that government labs are prohibited from proposing as performers or subcontractors. However, we've identified a government service lab that does a specialized type of wafer growth that we feel will be required for our technology to reach the program metrics. Would it be acceptable to purchase these wafers under a "Work For Non-Federal Entities Agreement" (WFNFE) or PO to the government lab? They would be compensated for providing materials and not for technical collaboration.

Answer: This may be acceptable only if such wafer growth is generally available to all interested parties and not only to the proposer, and if the arrangement does not involve the government lab providing a key innovation to the concept, providing a unique capability to enable the research project, performing research in any capacity, or advancing the government lab's capabilities to compete in the broader R&D field through the proposed work.

Question 56: [Timeline] Phase 1 is stated in the Program Solicitation (PS) as being 24 months. However, on slide 50, it looks like it could be only 12 months or 12+9 months (21 months), and then there is some potential for EPFT.

Answer: The PS is the official solicitation and takes precedence over Proposers Day documents, which must be considered informational tools.

Phase 1 will be 24 months. 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.

Question 57: [Fundamental Research] Can DARPA please clearly define "Fundamental Research, and explain the new change of Fundamental Research in reference security.

Answer: Please visit Proposer Instructions and General Terms and Conditions for specific information regarding Fundamental Research and the DARPA Fundamental Research Risk-Based Security Review Process detailed at the DARPA Fundamental Research Risk-Based Security Review Process detailed at Proposer Instructions: Other Transactions | DARPA.

"Fundamental research" means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.

Question 58: [Fundamental Research] Can you comment on any FRRBS needs for government team respondents?

Answer: FRRBS does not apply to Govt Team.

Question 59: [Scale-Up Period] In the optional 9-month Scale-Up Period, would DARPA consider multi-node, multi-species demonstrations if the same hardware supports both heterogeneous QC interconnects and long-distance quantum state distribution?

Answer: Yes. During the Scale-Up period, DARPA will begin planning specific interconnect architectures to pursue that are capable of heterogeneous quantum computing and long-distance quantum state preparation. These interconnects will be developed during the Expanded Program Follow-On Tasking (EPFT) period.

Question 60: [Scale-Up Period] On slide 50 of HARQ Proposers Day briefing, it states that: "After month 12 of Phase 1, DARPA may authorize, at its sole discretion, a 9-month Scale-Up period through a modification to the Agreement". Are there expected specific tasks and a month deadline per task during that 9-month scale-up period you can share?

Answer: The task of the Scale-Up Period is defined in the PS as "Finalize an end-to-end interconnect model, teaming arrangement, commercialization plan, and test plan at the CUI level, which combines multiple DARPA-PS-25-31 components from TA1 projects, interface methods from TA2 projects, and/or innovations from outside the HARQ program." Milestones by month are defined in the PS in Table 4. Scale Up Period Milestones.

Question 61: [Teaming] Early in the presentation, the DARPA Program Manager (Dr. Justin Cohen) mentioned potential opportunities for teaming. Could you provide some information about this? Are teams encouraged? If so, are there requirements on team size?

Answer: DARPA is open to teaming amongst the community as appropriate and when strategic to achieve program outcomes. Teaming between organizations is not required. There are no requirements on team size.

To facilitate the building of teams, Proposers Day registrants were given the option during registration whether they approved publication of their contact information. For those that opted in, their contact information was included in the HARQ Proposers Day attendee list and distributed to other prospective proposers that also opted in.

Per questions 3, 6, and 7, UARCs, FFRDCs, and government entities (including national laboratories) are prohibited from being a part of proposer teams.

During the program, additional teaming between performers will be encouraged by DARPA to prepare for the potential Scale-Up Period and EPFT.

Question 62: [Teaming] Are performers encouraged to team up before the Abstract submission deadline of August 28? Would a software developer organization be considered for a TA1 submission or they would need to partner with hardware providers?

Answer: DARPA is open to teaming amongst the community as appropriate and when strategic to achieve program outcomes, but teaming is not required. A strictly software modeling and simulation effort is in scope for TA1, and does not require teaming with a hardware team.

Question 63: [Scope] Are you looking for a novel solution or integration/adaptation of commercial solution would be considered?

Answer: DARPA will consider any concept with a path to meet the program goals, milestones, and metrics.

Question 64: [Scope] Can I propose a concept if some of it is outside the written scope of TA1 and TA2?

Answer: Abstracts and proposals that do not fall within the scope of the HARQ program may be submitted to DARPA through other avenues, such as an office-wide BAA.

Question 65: [Scope] Can proposals be software only, or is hardware design required?

Answer: Proposals for TA1 are expected to be theory, analysis, and software only. Separately, TA2 proposals are expected to address development of hardware prototypes supported by analytical modeling.

Question 66: [TA1, Technical Interchange] Will the Government Team define a standardized data format or interface for providing interconnect parameters to TA1 compilers, or will this be coordinated performer-to-performer during technical interchange meetings?

Answer: Yes, the government team will lead this task. The exact workflow and the format for parameter exchange between the performers and the government team will be defined early in the program and will consider inputs from the parties involved.

Question 67: [TA1, Scope] DARPA "expects that the primary TA1 activity will be to compile abstract circuits into physical circuits through an intermediate error correction layer". Can you elaborate on what valid approaches look like, beyond the Quera paper?

Answer: The Quera paper was referenced in the Proposers Day slides only as an illustrative example of translating between error correction codes, which may be a feature of TA1 approaches. This method is not required. The program is open to any concept that can leverage a quantum error correction scheme to compile and optimize abstract circuits into physical resource estimates. Note, proposals should not propose or develop any new quantum error correction schemes as part of this effort.

Question 68: [TA1, Scope] What are the requirements on accuracy or failure rate for the quantum error correction used in TA1?

Answer: The implementation of error correction in TA1 is not defined by DARPA. Proposers are encouraged to discuss how such parameters will be considered in their approach.

Question 69: [TA1, Scope] Is DARPA interested in a compiler that chooses the most efficient way of doing nonlocal gates, e.g., memory vs teleportation?

Answer: Any approach that could leverage heterogeneity to reduce resources is of interest.

Question 70: [TA1, Scope] Is DARPA expecting proposals to the 1000-logical-qubit final circuit to allocate >1k physical qubits? What is the maximum number of physical qubits we can use?

Answer: The TA1 final deliverable requires a compiler take in an abstract circuit of >1000 logical qubits and derive the optimal physical circuit. Assuming quantum error correction schemes are used, all outputs of the TA1 tool will require ancillary physical qubits. Since the program does not define any specific error correction scheme for the proposals, HARQ does not impose a maximum limit to the number of qubits in the physical circuit derived by the compiler.

Question 71: [TA1, Scope] Is Cyber Security an important part of HARQ or is it a lower priority in the beginning?

Answer: HARQ is not focused on cyber security or any other specific application of quantum computers.

Question 72: [TA1, Scope] In TA1, are the "interfaces" and "mosaics" described in the Program Solicitation envisioned on the logical qubit level? Are tools and compilers which also address more general quantum information processing tasks, where there is a significant potential for advantage in heterogeneous architectures, also of interest for TA1? Are these potentially an appropriate class of application to target for resource reduction, as noted in the Program Solicitation?

Answer: The PS defines interfaces as physical circuit layouts between different qubit species. Any concept that provides resource reduction with heterogeneous architectures and that indicates a path to meet TA1 metrics, milestones, and deliverables, will be considered.

Question 73: [TA2] Does the "transfer of quantum state" between physical qubits specifically refer to a remote SWAP gate between the two physical qubits?

Answer: The program does not require a specific method of quantum state transfer.

Question 74: [TA2, Scope] For species with slow clock cycles, e.g., atoms and ions, 10 MHz may be faster than the radiative lifetime (not just the overhead processes for cooling and shuttling). Is there a distinction between natural lifetime limitations and overhead process limitations? If so, should we assume there will be rate-performance enhancements if we are focusing on other components in the system? In other words, how can we place reasonable upper bounds on the assumptions that improve individual qubit metrics?

Answer: TA2 metrics do not include end-node qubit parameters regardless of them being driven by natural or overhead processes. Components comprising the interconnect models must enable 10 MHz transfer rates when connected to end-node qubits capable of operating at such rates, but interconnects are expected to run slower when connected to slower qubits, e.g. atoms and ions.

Question 75: [TA2, Scope] Will DARPA prioritize integrated "interconnect node" demonstrations that combine multiple components over single-component performance demonstrations, provided both approaches contribute to end-to-end interconnect modeling?

Answer: No, the focus of TA2 is at the component level except for Track D. Integrated demonstrations that combine multiple components may be proposed to Track D. All proposals to all tracks will be assessed on their individual merits to accomplishing the goals, metrics, and deliverables.

Question 76: [TA2, Scope] In principle, if a TA2 platform can interconnect with multiple qubit modalities through tuning or frequency conversion, but only demonstrates one exemplar heterogeneous link experimentally, would this satisfy the interoperability expectations for the base period?

Answer: TA2 performers are not required to experimentally demonstrate a complete heterogeneous interconnect link during Phase 1; rather, they must develop and demonstrate components that would enable an interconnect. The analytical interconnect models that are included in proposals may address exemplar qubit modalities, and will be generalized during the program.

Question 77: [TA2, Scope] Is the expectation to focus solely on component-level modeling, or to co-develop interconnect simulation tools in collaboration with the Government Team for integration into heterogeneous architecture studies?

Answer: TA2 performers are expected to focus on hardware component development, and support the modeling and simulation needed to validate that their component performance enables the target interconnect performance metric.

Question 78: [TA2, Scope] Is there specific interest in materials with inherent radiation hardness and integrated photonics capability, such as silicon carbide (SiC), for defense-relevant heterogeneous QC deployments?

Answer: No, radiation hardness is not a goal of the program. Integrated photonics is one of the technologies of interest enabling quantum interconnects to be developed in TA2.

Question 79: [TA2, Scope] For optical frequency converters, will DARPA provide prioritized wavelength pairs for conversion during the program, or should proposals select and justify their own targets based on anticipated qubit modalities?

Answer: Abstracts and Proposals should select and justify their own targets based on exemplar qubit modalities, and provide a rationale for how the concept can address other wavelengths. During the program, DARPA may identify prioritized wavelength pairs for experimental demonstrations.

Question 80: [TA2, Scope] If TA2 hardware meets component-level metrics ahead of schedule, would DARPA be open to integrating it into larger-scale heterogeneous testbeds or government-managed demonstrations during Phase 1?

Answer: Yes, contingent on results obtained during Phase 1 and availability of funds, DARPA may authorize the Scale-Up Period from month 12 onwards to pursue integration into larger-scale heterogeneous testbeds or government-managed demonstrations. If the Scale-Up Period is authorized between months 12-24, it will run concurrently with Phase 1.

Question 81: [TA2, Scope] Is multiplexing to increase rate of module interconnection in or out of scope?

Answer: Concepts that primarily rely on multiplexing using end-node qubit resources are discouraged. Any concepts that employ multiplexing should provide a rationale for how they minimize end-node qubit overhead. Multiplexing using qubits within the interconnect is in scope and preferred, since this does not contribute to the end-node qubit overhead.

Question 82: [TA2, Scope] In the case that we use a specific qubit type for both frequency conversion in optical frequencies and transduction between optical and microwave frequencies, could we submit one proposal to address both Track B and Track C?

Answer: Abstracts and proposals to multiple TA2 Tracks must be submitted separately.

Question 83: [TA2, Scope] Are we allowed to include "quantum-inspired processors/modules" (e.g., FPGA/custom-design ASIC) as part of our heterogeneous quantum architecture, as these modules can bring down the cost significantly, they are much more energy efficient, and they can be even much faster for certain subproblems/sub-circuits?

Answer: Such devices can be part of proposed solutions, but appear to be insufficient as a standalone component for heterogeneous interconnects sought in TA2. Proposals that pursue such solutions should clearly identify how such quantum-inspired processors and modules will contribute to interconnect performance to yield the relevant metrics listed in the program solicitation.

Question 84: [TA2, Scope] Is telecom (1550 nm or 1260 nm) connection a key consideration to be involved or not?

Answer: HARQ does not require a specific operating wavelength for interconnects.

Question 85: [TA2, Scope] Are interconnects between, e.g., modalities within the superconducting circuits (such as transmons, 3D storage cavities, fluxoniums) of interest for TA2?

Answer: No, such local interconnects are not of interest except insofar as they enable interconnects between superconducting qubits and other qubit species (e.g. atoms, ions).

Question 86: [TA2, Scope] Would HARQ be interested in geographically displaced quantum computers and communication between them?

Answer: HARQ proposals should target interconnect solutions that enable connections between nodes that are separated by ~10 meters to few kilometers. Solutions scoped beyond that range will be considered, but are not required.

Question 87: [TA2, Scope] We found the framing of the arbitrary wavelength conversion (UVA-NIR) somewhat confusing. Is it expected that there should be a generalized approach to wavelength conversion? Are you seeking approaches that don't face material and process limitations that confine them to specific wavelength bands? I.e., are approaches expected to be continuously tunable?

Answer: While a continuously tunable solution certainly falls within the scope of TA2 Track B, DARPA does not expect solutions to be continuously tunable across the entire range of UVA to NIR. Proposals and abstracts should identify how the proposed concept can be modified and/or extended without excessive redevelopment to allow conversion between arbitrary wavelengths in the UVA-NIR range. This could entail modifying geometries, selecting different materials without requiring significantly new processing, or another novel solution.

Question 88: [TA2, Scope] We have a unique solution that doesn't seem to clearly fit in the into the TA2 track structure. DARPA's interconnect schemes seem to be based on probabilistic architectures. How should we propose?

Answer: Abstracts and Proposals that do not clearly fall under Tracks A-C of TA2 should propose under TA2 Track D.

Question 89: [TA2, Metrics] The 10-MHz state transfer rate and 99.9% fidelity targets are highly ambitious for heterogeneous links. Will DARPA consider proposals that present a credible technical roadmap to these metrics within the base period, or is full achievement expected before the conclusion of the initial phase?

Answer: The interconnect-level metrics are expected to be met through analysis in Phase 1, supported by experimental demonstrations of component-level metrics. TA2 proposers must indicate a credible path to achieving the metrics in this manner, using the baseline and target performance specifications sections of the proposal to distinguish clearly achievable metrics versus higher-risk metrics.

Question 90: [TA2, Metrics] In the case of the microwave-to-optical converter topic, would state-transfer rate correspond to the "transit-time" of the quantum information through the device?

Answer: State transfer rate here refers to the number of quantum states that can be transferred across an interconnect per unit time (i.e., 10 MHz = 10 million quantum states transferred per second)

Question 91: [TA2, Metrics] The highlighted purpose of the memory was to boost rates in the presence of a lossy channel; however, it seems as if we're expected to determine component performance based on an optimized channel. Especially given that the channel length is only 10 m, how should we reconcile the need for a memory to boost rates while still hitting the interconnect system specifications? If the other components in the chain are sufficiently good, the memory becomes effectively redundant. In other words, how should we frame the requirements for the memory in this case?

Answer: The interconnect channel is not expected to be "optimal". DARPA expects that losses in interfacing with diverse end-node qubit species will be appreciable, and frequency conversion/transduction is also expected to incur loss. While not required, DARPA expects that these types of loss parameters are likely to drive the enhancement provided by memories in interconnect models.

Question 92: [TA2, Metrics] Are the 10-MHz rate and 99.9% fidelity required to be met with baseline or target specifications? Beyond the proposed component that will be enhanced beyond state-of-art, do we assume state-of-art or (reasonably) beyond state-of-art on all other components to reach 10-MHz rate and 99.9% fidelity?

Answer: Baseline specifications are expected to fall short of metrics. Target specifications should meet or exceed metrics to be responsive. Target specifications can assume the proposed component that exceeds current state-of-art as well as additional components that also exceed current state-of-art.

Question 93: [TA2, Scope] Would a team that proposes to achieve photon teleportation in all RF and not optical be considered for award?

Answer: Yes, if such a team can also demonstrate how their approach can augment, abet, or interface with other components to enable heterogeneous interconnects.

Question 94: [Proposers Day] Will the proposer profiles we submitted for Proposers Day be posted to Sam.gov?

Answer: Proposer profiles will not be posted to Sam.gov. The proposer profiles were shared via email on Aug 12th with all approved Proposers Day attendees who agreed to share their contact information.