Quantum Benchmarking Initiative (QBI)

Joe Altepeter, Ph.D.
Program Manager, Microsystems Technology Office

Proposers Day

September 3, 2024



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Questions and answers

Please use the program email address to submit questions for the government team

- QBI@DARPA.mil

For questions submitted today before 12:30 PM, we will attempt to answer them this afternoon, time permitting

- See Proposers Day agenda for more details

Questions submitted after 12:30 PM today will have answers posted periodically to the FAQ list on the DARPA Opportunities website

- https://www.darpa.mil/work-with-us/opportunities

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QBI → Bottom line up front

Are you going to build an **industrially useful** quantum computer by 2033?

If so, we'd like to hear from you.

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How can QBI help your effort to build a quantum computer?

a. Provide funding
b. Provide unbiased Verification and Validation (V&V)
c. Communicate results to U.S. Government stakeholders

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QBI Motivation – Separating Hype from Reality

Economic Opportunity

- It has been **credibly hypothesized** – but not proven – that quantum computers would have a **transformational impact** on many industries.
- **Examples:** Machine learning, quantum chemistry, materials discovery, molecular simulation, many-body physics, classification, nonlinear dynamics, supply chain optimization, drug discovery, battery catalysis, genomic analysis, fluid dynamics, protein structure prediction, solving systems of linear and nonlinear equations.



Pharmaceuticals ($145B Market)



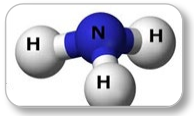
Image Recognition ($109B Market)



Battery Catalysis ($141B Market)



Machine Learning ($97B Market)



Nitrogen Fixation ($85B Market)



Encryption ($146B Market)

Sources: Shutterstock

Security Threat

- **NIST analysis of the threat:**
  *"If large-scale quantum computers are ever built, they will be able to break many of the public-key cryptosystems currently in use. This would **seriously compromise** the confidentiality and integrity of digital communications on the Internet and elsewhere."*
- **NIST on the timeline for cryptographically relevant quantum computers:**
  *"Some engineers even predict that **within the next twenty or so years** sufficiently large quantum computers will be built to break essentially all public key schemes currently in use."*



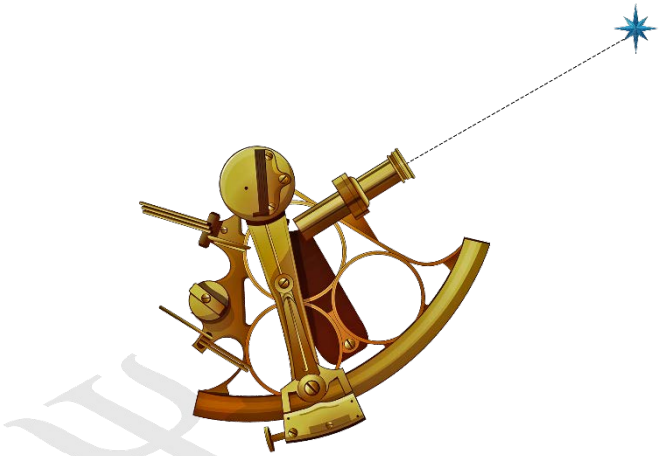
Source: Shutterstock

If the hype is real, utility-scale quantum computers have the potential for significant economic disruption

[Quotes from: *https://csrc.nist.gov/projects/post-quantum-cryptography]*

What questions are we trying to answer in QBI?

QBI expands upon work done in two DARPA programs – they were designed to answer these questions:



Quantum Benchmarking

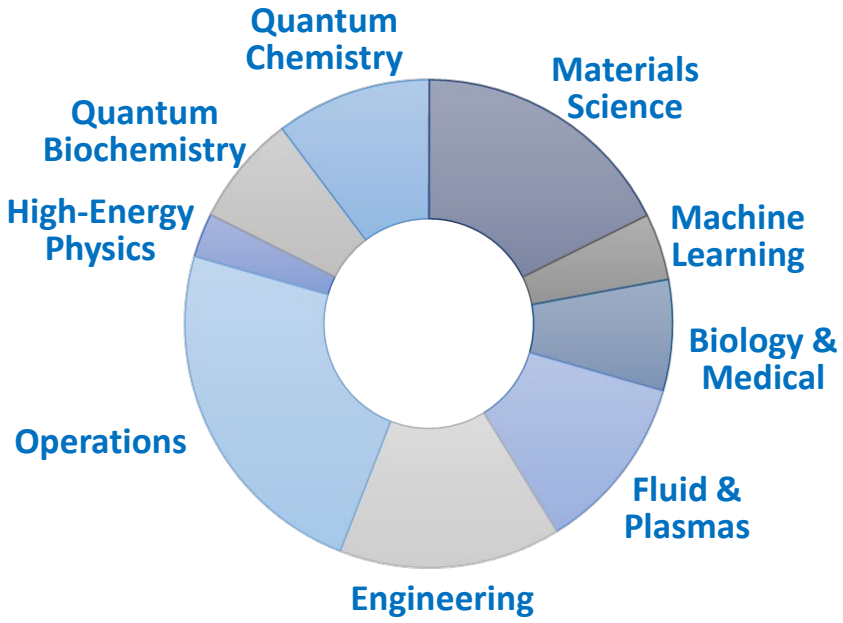
Would a very powerful quantum computer be industrially useful?



Can efforts to build a very powerful quantum computer in the near term succeed?

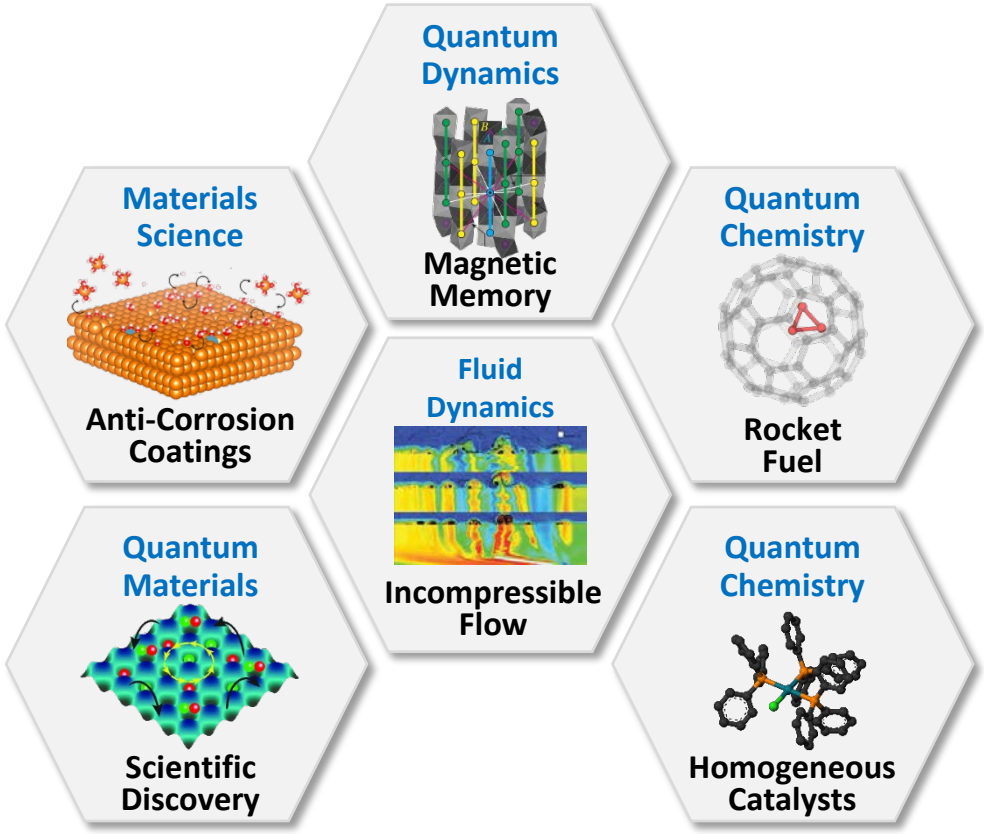
What applications may be useful?

More than 200 applications were documented by DARPA's Quantum Benchmarking Program in 2022



Staff Experts (50 FTE total)	61	Industry	35	Government
	83	University	8	Nonprofit

Using available resources, DARPA has prioritized ~15 applications for examination

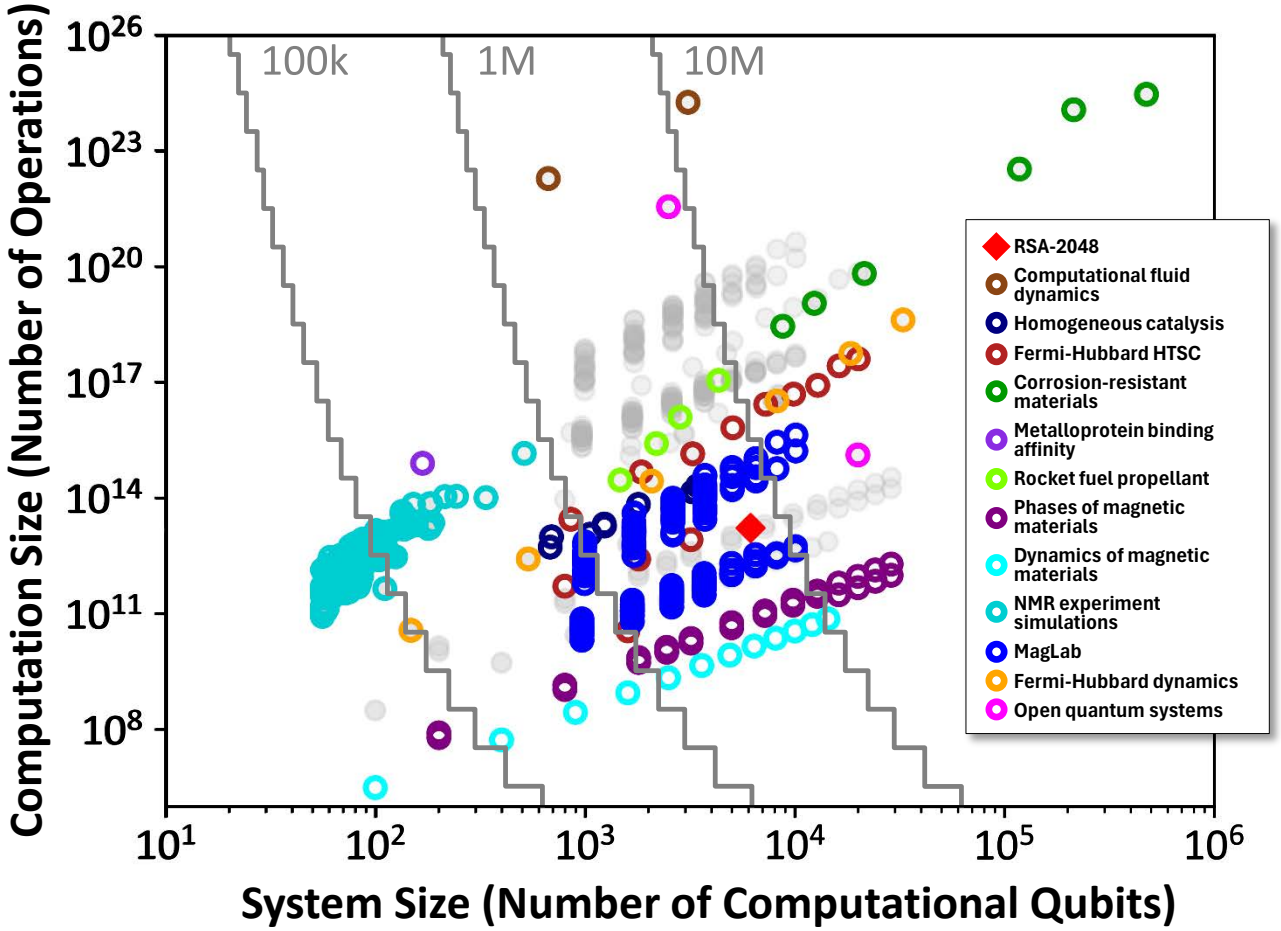


DARPA is examining quantum utility for a few key problem classes, but many more remain

Preliminary results from Quantum Benchmarking

Applications that could benefit from a quantum coprocessor:

- Simulating correlated materials
- Developing corrosion resistant materials
- Developing new rocket fuels and explosive materials
- Dynamical simulations (for new solar cells, better understanding of biological processes, and magnetic materials)
- New methods to compile algorithms to fault-tolerant quantum architectures



Grey solid circles represent pessimistic resource estimates. Colored circles are optimistic resource estimates based on known improvements. All points supported by detailed published pre-prints.

Preliminary evidence suggests that large-scale quantum computers could be industrially useful

Verifying and validating hardware paths to utility-scale

The primary goal of QBI is to determine if any approach to quantum computing can achieve utility-scale operation by the year 2033

- Although DARPA considers this unlikely, if the QBI Test and Evaluation (T&E) team successfully verifies and validates that an approach can achieve utility-scale operation by the year 2033, DARPA intends to aggressively communicate these results to U.S. Government Agencies interested in using or acquiring such a machine

QBI expands upon the existing DARPA US2QC program

- While current US2QC performers are not precluded from proposing new approaches to Stage A of this solicitation, QBI is intended to address new developments in the quantum computing field
- Active US2QC performers are subject to the terms of their agreements awarded under DARPA-PS-22-04, which parallels QBI
- Organizations that have completed US2QC Phase 0 but are not currently US2QC performers may submit an Abstract per this solicitation



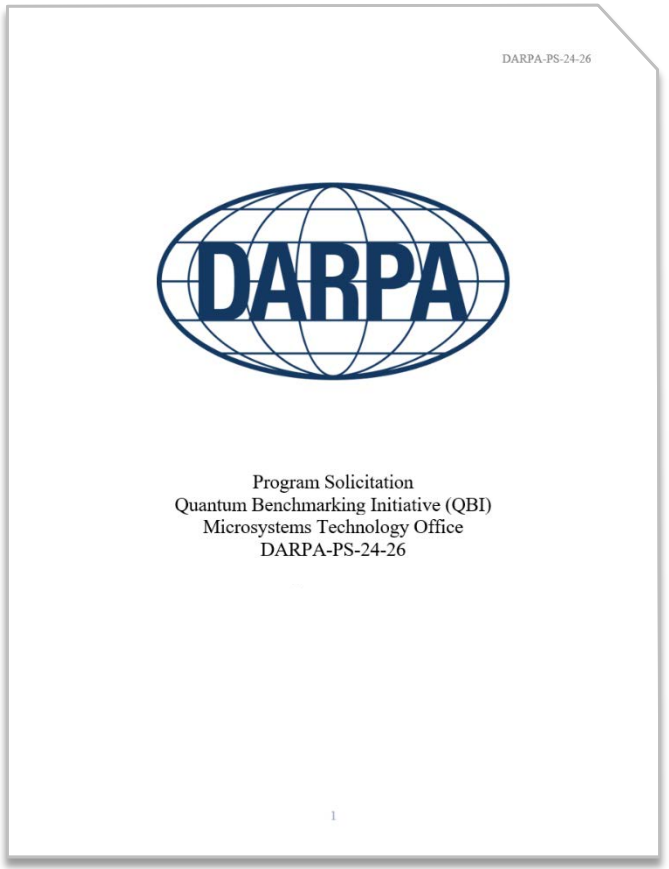
QBI aims to discover if any company is on the path to creating an industrially useful quantum computer by 2033

QBI Program Solicitation

A new program solicitation

was released last week

QBI Quantum Benchmarking Initiative



This solicitation is seeking proposals from any organization that believes they are on the path to build a utility-scale quantum computer in the near term

Stages of QBI

QBI Stage A:
Plausibility

6-months
Up to $1M*

QBI Stage B:
R&D Plan

12-months
Up to $15M*

QBI Stage C:
Validation and Co-Design

Duration tailored to performer
Up to $300M*

**see PS for details and conditions*

Stage A

- Will focus on the performer's utility-scale quantum computer (USQC) concept

Stage B

- Will focus on examining the performer's baseline research and development (R&D) plan

Stage C

- Will determine if a USQC can be constructed as designed and operated as intended

QBI will focus on verifying and validating the path to utility-scale quantum computers, and will not focus on tracking incremental improvements to the state of the art

QBI Stage A – Plausibility

- A **six (6)-month period of performance** will focus on the USQC concept
- **In the first three (3) months**, a performer will **develop a system concept report** to be delivered to the Government Test and Evaluation (T&E) team and reviewed at a concept design review in month four (4)
- This report will detail the performer's approach to building a utility-scale quantum computer (see Attachment G for an example report outline)
- **During the last three (3) months** of this stage, **the T&E team will evaluate and provide feedback** on the draft concept report culminating in a presentation of the Government Team's understanding of the performer's baseline system architecture and the performer's delivery of a revised report
- Performers in Stage A may accelerate the delivery of their milestones, giving DARPA the opportunity to evaluate their concept and begin discussions about advancement to Stage B earlier than the six-month timeline



QBI Stage B – Research and Development Plan

- A **twelve (12)-month period of performance** will focus on examining:
  - The performer's **baseline research and development (R&D) plan** to build the USQC
  - The **risks associated with that plan** and the planned risk mitigation steps
  - The **prototypes that the T&E team can validate** during Stage C in order to give confidence that the risks to build a USQC have been sufficiently reduced that construction and final design could begin immediately

- Stage B will enable DARPA to:
  - Evaluate the R&D plan for the USQC concept
  - Expand the utility-scale system evaluation
  - Gain visibility into ongoing progress on critical components development
  - Define and prepare for initial Stage C experimental evaluations



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QBI Stage C – Validation and Co-Design

- This stage will consist of a **variable period of performance** tailored to a specific performer's R&D plan but is assumed for cost estimates to be nominally 36 months
- This Stage **will determine if a USQC can be constructed as designed and operated as intended**
- More specifically, the four primary goals of Stage C will enable DARPA to:
  - Evaluate the utility-scale system design finalization
  - Perform component testing and direct hardware evaluation
  - Assess the system-level performance capabilities of major prototypes
  - Engage in application and algorithm co-design (if appropriate)

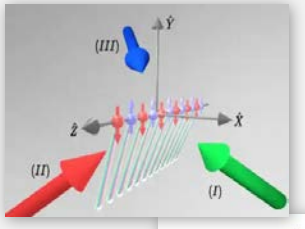


Companies that successfully complete Stage C will be those that DARPA deems are ready to immediately begin the final design and construction of a USQC whose value exceeds its cost

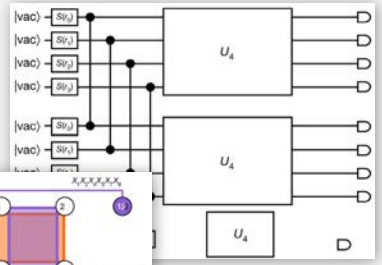
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Test and Evaluation (T&E) approach for Stage A

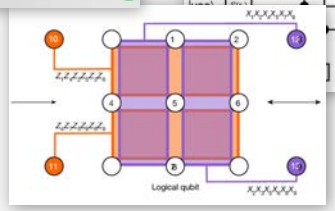
Deep, Targeted Analysis
(Physics teams)



Source: PhysRev-Research



Source: Nature

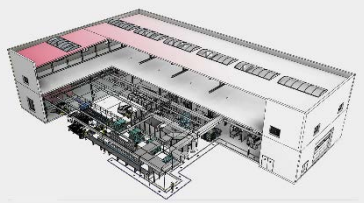


Source: Nature

Broad System Evaluation
(Systems Engineering teams)



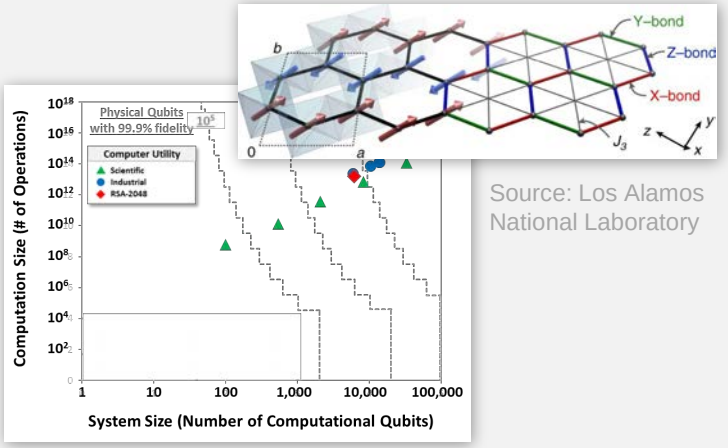
Source: Shutterstock



Source: Autodesk

ID	Task Name	Predecessors	Duration
1	Start		0 days
2	a	1	4 days
3	b	1	5.33 days
4	c	2	5.17 days
5	d	2	6.33 days
6	e	3,4	5.17 days
7	f	5	4.5 days
8	g	6	5.17 days
9	Finish	7,8	0 days

Utility Estimation
(Applications teams)



Source: Los Alamos National Laboratory

T&E System Evaluation Methodology for Stage A

Roots (3)

USQC Physical Decomposition

- What is a high-level description of a Utility Scale Quantum Computer?
- What are all the components and sub-systems and how do they fit together?
- What happens at the interfaces of those components and sub-systems?

USQC Functional Decomposition

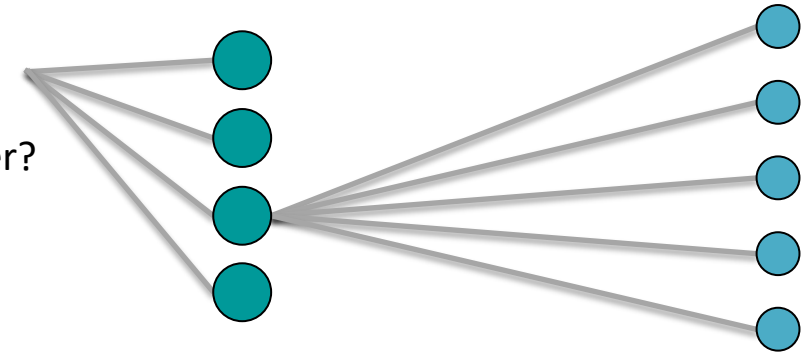
- How does the proposed USQC actually work?
- How is it intended to be used?
- What are its intended modes of operation and user interfaces?

Performer Processes

- What processes, plans, and products does this team have in place?
- How have they leveraged those (or different) processes, plans, products, in the past to come to their current USQC concept?
- How will the team's processes, plans, products change or be leveraged in the future to burn down all the risks and actually be ready to start USQC construction?

Branches (16)

Leaves (50)

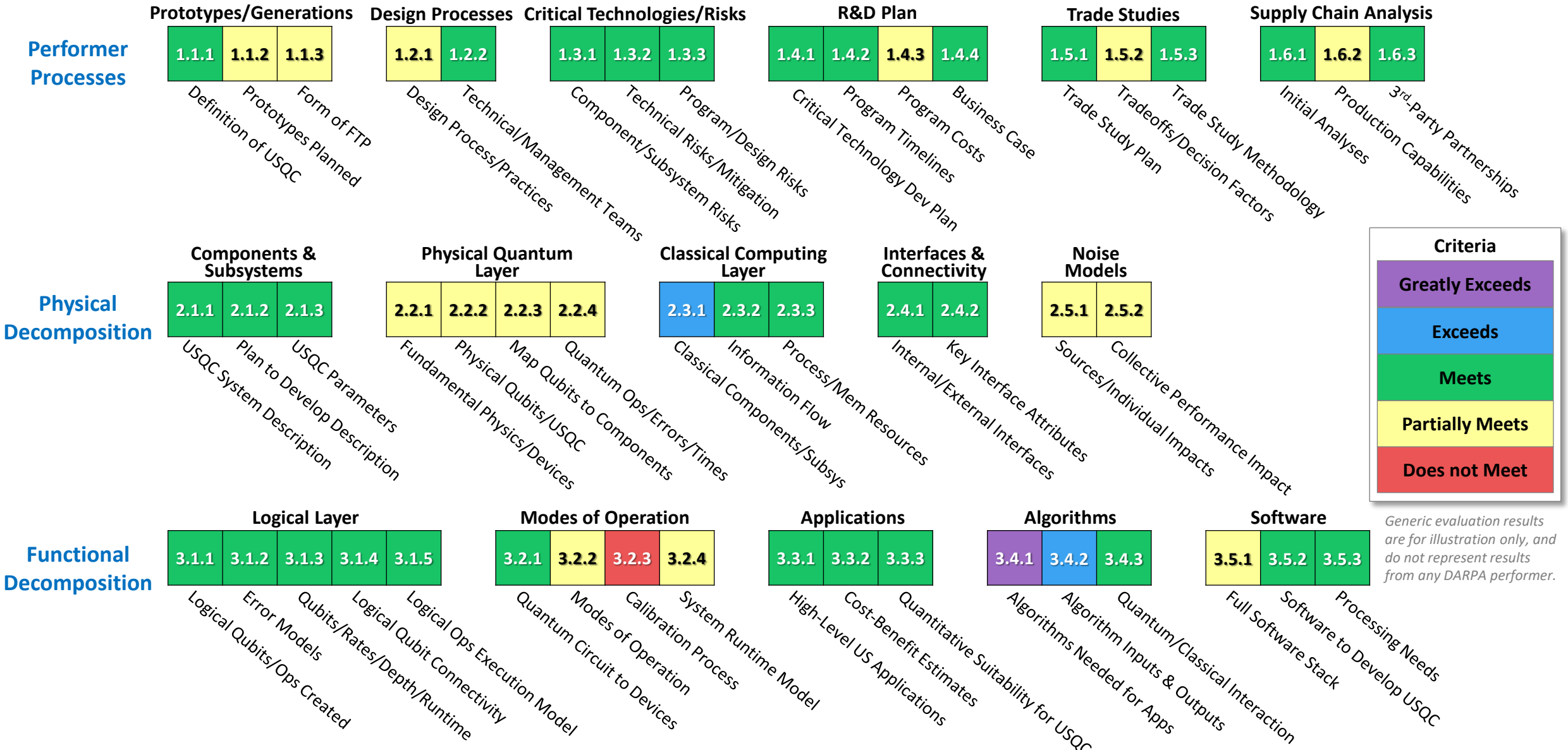


Example Branch
Components and Subsystems

Example Leaf
System description of the USQC including a graphic depiction of the components and subsystems

System Evaluation → Provide a broad evaluation of the completeness and quality of concepts

System evaluation – generic example



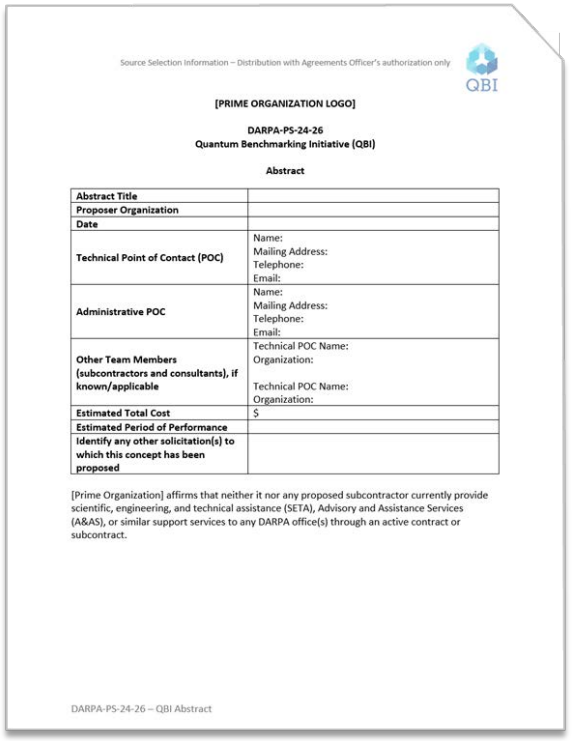
Generic evaluation results are for illustration only, and do not represent results from any DARPA performer.

Critical steps for a QBI performer

Abstract → Oral Proposal Package → OT Award Negotiation → Stage A → Stage B → Stage C

Required – Proposers cannot be selected for funding unless they submit an abstract

Format – Eight (8) pages; see the Program Solicitation for detail



Source Selection Information – Distribution with Agreements Officer's authorization only

QBI

[PRIME ORGANIZATION LOGO]

DARPA-PS-24-26
Quantum Benchmarking Initiative (QBI)

Abstract

Abstract Title	
Proposer Organization	
Date	
Technical Point of Contact (POC)	Name: Mailing Address: Telephone: Email:
Administrative POC	Name: Mailing Address: Telephone: Email:
Other Team Members (subcontractors and consultants), if known/applicable	Technical POC Name: Organization: Technical POC Name: Organization:
Estimated Total Cost	$
Estimated Period of Performance	
Identify any other solicitation(s) to which this concept has been proposed	

[Prime Organization] affirms that neither it nor any proposed subcontractor currently provide scientific, engineering, and technical assistance (SETA), Advisory and Assistance Services (A&AS), or similar support services to any DARPA office(s) through an active contract or subcontract.

DARPA-PS-24-26 – QBI Abstract

Critical steps for a QBI performer



Invitation Only – Only proposers who submit an abstract and are then invited to submit an Oral Proposal Package may do so

Format – Two (2) presentations on a single day plus supplementary documents

- Full details will be sent with an invitation to give an Oral Proposal

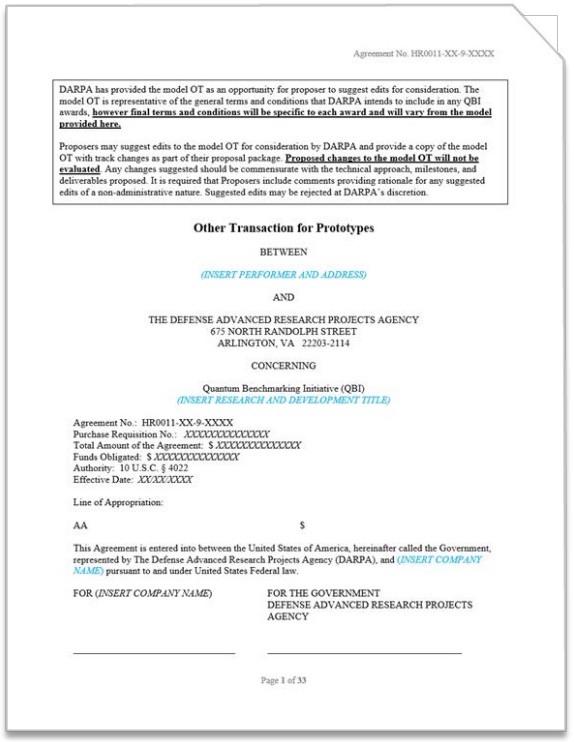
Live Questions – The Government evaluation team will ask questions in real time

Proposal is for Stage A – Next Stage to be negotiated after the start of Stage A

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Critical steps for a QBI performer

Abstract → Oral Proposal Package → **OT Award Negotiation** → Stage A → Stage B → Stage C



Agreement No. HR0011-XX-9-XXXX

DARPA has provided the model OT as an opportunity for proposer to suggest edits for consideration. The model OT is representative of the general terms and conditions that DARPA intends to include in any QBI awards, **however final terms and conditions will be specific to each award and will vary from the model provided here.**

Proposers may suggest edits to the model OT for consideration by DARPA and provide a copy of the model OT with track changes as part of their proposal package. **Proposed changes to the model OT will not be evaluated**. Any changes suggested should be commensurate with the technical approach, milestones, and deliverables proposed. It is required that Proposers include comments providing rationale for any suggested edits of a non-administrative nature. Suggested edits may be rejected at DARPA's discretion.

Other Transaction for Prototypes

BETWEEN

(INSERT PERFORMER AND ADDRESS)

AND

THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
675 NORTH RANDOLPH STREET
ARLINGTON, VA 22203-2114

CONCERNING

Quantum Benchmarking Initiative (QBI)
(INSERT RESEARCH AND DEVELOPMENT TITLE)

Agreement No.: HR0011-XX-9-XXXX
Purchase Requisition No.: *XXXXXXXXXXXXX*
Total Amount of the Agreement: $ *XXXXXXXXXXXXX*
Funds Obligated: $ *XXXXXXXXXXXXX*
Authority: 10 U.S.C. § 4022
Effective Date: *XX/XX/XXXX*

Line of Appropriation:

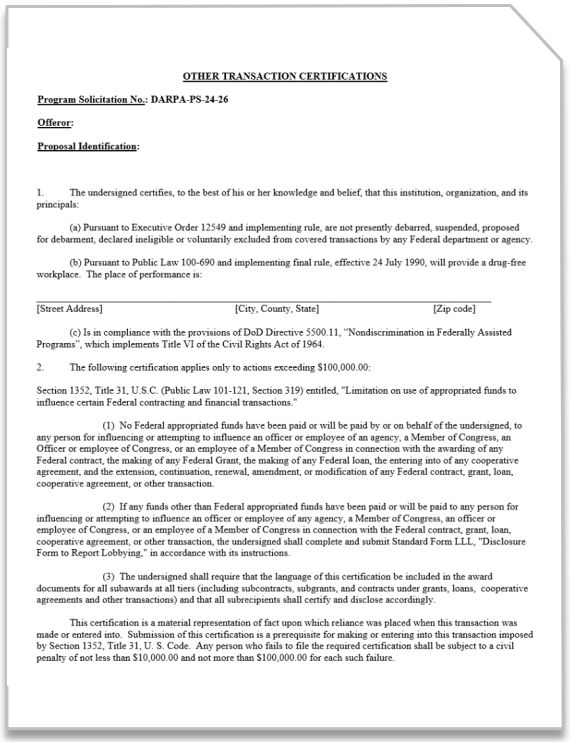
AA $

This Agreement is entered into between the United States of America, hereinafter called the Government, represented by The Defense Advanced Research Projects Agency (DARPA), and *(INSERT COMPANY NAME)* pursuant to and under United States Federal law.

FOR *(INSERT COMPANY NAME)*

FOR THE GOVERNMENT
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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OTHER TRANSACTION CERTIFICATIONS

Program Solicitation No.: DARPA-PS-24-26

Offeror:

Proposal Identification:

1. The undersigned certifies, to the best of his or her knowledge and belief, that this institution, organization, and its principals:

(a) Pursuant to Executive Order 12549 and implementing rule, are not presently debarred, suspended, proposed for debarment, declared ineligible or voluntarily excluded from covered transactions by any Federal department or agency.

(b) Pursuant to Public Law 100-690 and implementing final rule, effective 24 July 1990, will provide a drug-free workplace. The place of performance is:

[Street Address] [City, County, State] [Zip code]

(c) Is in compliance with the provisions of DoD Directive 5500.11, "Nondiscrimination in Federally Assisted Programs", which implements Title VI of the Civil Rights Act of 1964.

2. The following certification applies only to actions exceeding $100,000.00:

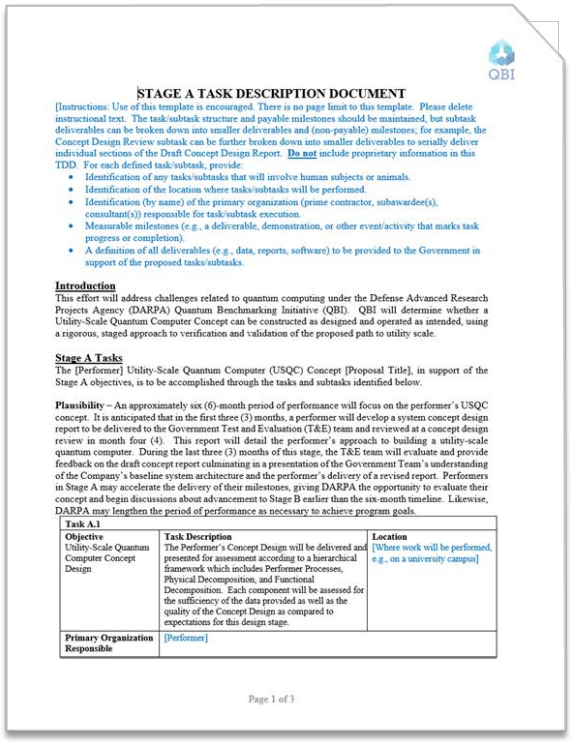
Section 1352, Title 31, U.S.C. (Public Law 101-121, Section 319) entitled, "Limitation on use of appropriated funds to influence certain Federal contracting and financial transactions."

(1) No Federal appropriated funds have been paid or will be paid by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an Officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal Grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, cooperative agreement, or other transaction.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the Federal contract, grant, loan, cooperative agreement, or other transaction, the undersigned shall complete and submit Standard Form LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, cooperative agreements and other transactions) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U. S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000.00 and not more than $100,000.00 for each such failure.



QBI

STAGE A TASK DESCRIPTION DOCUMENT

[Instructions: Use of this template is encouraged. There is no page limit to this template. Please delete instructional text. The task/subtask structure and payable milestones should be maintained, but subtask deliverables can be broken down into smaller deliverables and (non-payable) milestones; for example, the Concept Design Review subtask can be further broken down into smaller deliverables to serially deliver individual sections of the Draft Concept Design Report. **Do not** include proprietary information in this TDD. For each defined task/subtask, provide:

- Identification of any tasks/subtasks that will involve human subjects or animals.
- Identification of the location where tasks/subtasks will be performed.
- Identification (by name) of the primary organization (prime contractor, subawardee(s), consultant(s)) responsible for task/subtask execution.
- Measurable milestones (e.g., a deliverable, demonstration, or other event/activity that marks task progress or completion).
- A definition of all deliverables (e.g., data, reports, software) to be provided to the Government in support of the proposed tasks/subtasks.

Introduction

This effort will address challenges related to quantum computing under the Defense Advanced Research Projects Agency (DARPA) Quantum Benchmarking Initiative (QBI). QBI will determine whether a Utility-Scale Quantum Computer Concept can be constructed as designed and operated as intended, using a rigorous, staged approach to verification and validation of the proposed path to utility scale.

Stage A Tasks

The [Performer] Utility-Scale Quantum Computer (USQC) Concept [Proposal Title], in support of the Stage A objectives, is to be accomplished through the tasks and subtasks identified below.

Plausibility – An approximately six (6)-month period of performance will focus on the performer's USQC concept. It is anticipated that in the first three (3) months, a performer will develop a system concept design report to be delivered to the Government Test and Evaluation (T&E) team and reviewed at a concept design review in month four (4). This report will detail the performer's approach to building a utility-scale quantum computer. During the last three (3) months of this stage, the T&E team will evaluate and provide feedback on the draft concept report culminating in a presentation of the Government Team's understanding of the Company's baseline system architecture and the performer's delivery of a revised report. Performers in Stage A may accelerate the delivery of their milestones, giving DARPA the opportunity to evaluate their concept and begin discussions about advancement to Stage B earlier than the six-month timeline. Likewise, DARPA may lengthen the period of performance as necessary to achieve program goals.

Task A.1		
Objective Utility-Scale Quantum Computer Concept Design	**Task Description** The Performer's Concept Design will be delivered and presented for assessment according to a hierarchical framework which includes Performer Processes, Physical Decomposition, and Functional Decomposition. Each component will be assessed for the sufficiency of the data provided as well as the quality of the Concept Design as compared to expectations for this design stage.	**Location** [Where work will be performed, e.g., on a university campus]
Primary Organization Responsible	[Performer]	

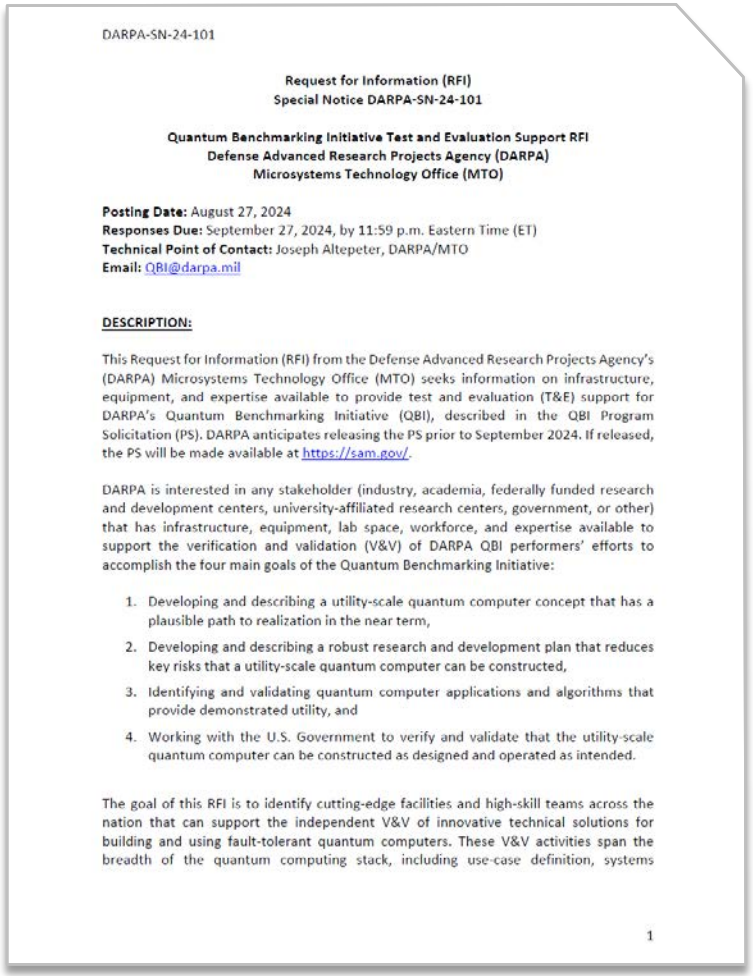
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QBI Test and Evaluation Request for Information (RFI)

The QBI program will build from the US2QC program, significantly expanding on the world-class Test & Evaluation team created for that program

➔ **If you are interested in partnering with DARPA to Test and Evaluate quantum computing technology, you can respond to the RFI**

- DARPA-SN-24-101
- Released August 27, 2024
- Responses due September 27, 2024



DARPA-SN-24-101

Request for Information (RFI)
Special Notice DARPA-SN-24-101

Quantum Benchmarking Initiative Test and Evaluation Support RFI
Defense Advanced Research Projects Agency (DARPA)
Microsystems Technology Office (MTO)

Posting Date: August 27, 2024
Responses Due: September 27, 2024, by 11:59 p.m. Eastern Time (ET)
Technical Point of Contact: Joseph Altepeter, DARPA/MTO
Email: QBI@darpa.mil

DESCRIPTION:

This Request for Information (RFI) from the Defense Advanced Research Projects Agency's (DARPA) Microsystems Technology Office (MTO) seeks information on infrastructure, equipment, and expertise available to provide test and evaluation (T&E) support for DARPA's Quantum Benchmarking Initiative (QBI), described in the QBI Program Solicitation (PS). DARPA anticipates releasing the PS prior to September 2024. If released, the PS will be made available at https://sam.gov/.

DARPA is interested in any stakeholder (industry, academia, federally funded research and development centers, university-affiliated research centers, government, or other) that has infrastructure, equipment, lab space, workforce, and expertise available to support the verification and validation (V&V) of DARPA QBI performers' efforts to accomplish the four main goals of the Quantum Benchmarking Initiative:

1. Developing and describing a utility-scale quantum computer concept that has a plausible path to realization in the near term,
2. Developing and describing a robust research and development plan that reduces key risks that a utility-scale quantum computer can be constructed,
3. Identifying and validating quantum computer applications and algorithms that provide demonstrated utility, and
4. Working with the U.S. Government to verify and validate that the utility-scale quantum computer can be constructed as designed and operated as intended.

The goal of this RFI is to identify cutting-edge facilities and high-skill teams across the nation that can support the independent V&V of innovative technical solutions for building and using fault-tolerant quantum computers. These V&V activities span the breadth of the quantum computing stack, including use-case definition, systems

1

Partnership with the Department of Energy

The Department of Energy is a critical DARPA partner in the QBI program

A recently-announced Memorandum of Understanding (MOU) between the Agencies enables robust collaboration on quantum computing Test & Evaluation



QBI

Partnership with Illinois – The Quantum Proving Ground

The State of Illinois is a key partner in the QBI Program

- Illinois is independently building a $500M Illinois Quantum and Microelectronics Park (IQMP), dedicated to scaling industrial quantum computing
- As part of this campus, DARPA and Illinois are co-investing in the **"Quantum Proving Ground",** an effort dedicated to enabling world-class Test and Evaluation for the Quantum Benchmarking Initiative
- IL is investing up to $140M in matching funds for the Quantum Proving Ground, which will directly contribute to the success of QBI

Why would a performer choose to work with the IQMP?

- State of Illinois will invest in equipment, infrastructure, physical and cyber security, and it may offset costs for prototype quantum computing hardware
- Participating performers gain access to the IQMP community, including state of IL university & national lab researchers, companies, suppliers, IL talent pipeline

These resources are available to QBI, but teams are **not required** to move to Illinois or to take advantage of these facilities and services.

QBI will do T&E wherever it makes the most sense.



Source: Lamar Johnson Collaborative

How should I get involved if….

… I am going to build a utility-scale quantum computer by 2033

→ Apply to Stage A via the QBI Program Solicitation

… I'm interested in participating in the Government T&E Team?

→ Respond to the T&E Special Notice

… I think I can build a utility-scale quantum computer, but only with DARPA's support

→ Your effort is probably not mature enough for this program, but you are welcome to apply

… I am interested in supporting a company trying to build a utility-scale quantum computer

→ You should contact those companies directly about supporting their proposal

… I am interested in related academic research, but am not planning on building a utility-scale quantum computer

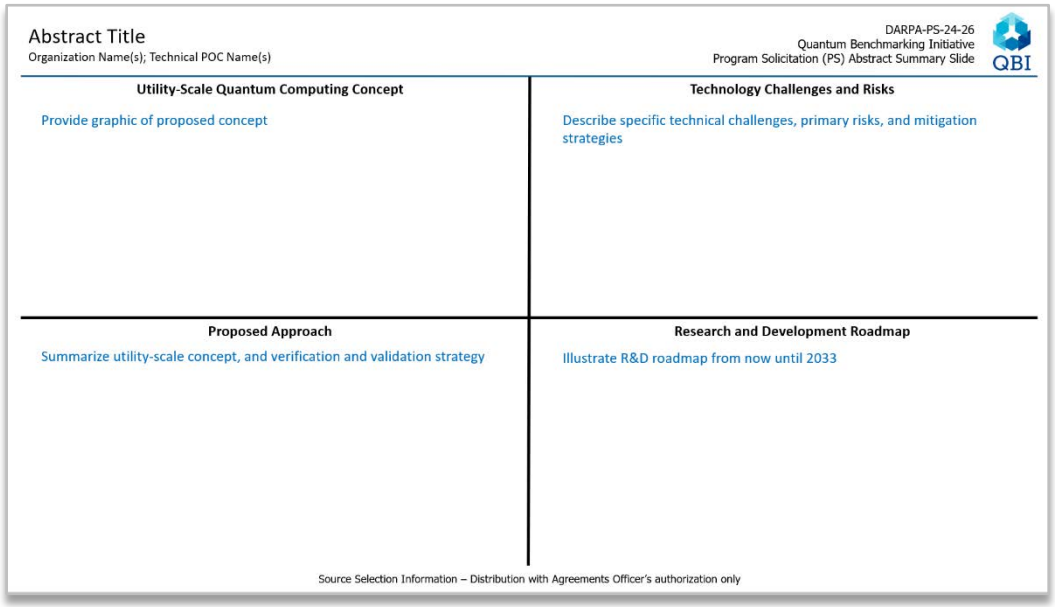
→ It is unlikely your work is appropriate for this solicitation

QBI

Attachment A – QBI Abstract Summary Slide Template

Template for PowerPoint slide that summarizes your utility-scale concept and approach

Required with Abstract submission

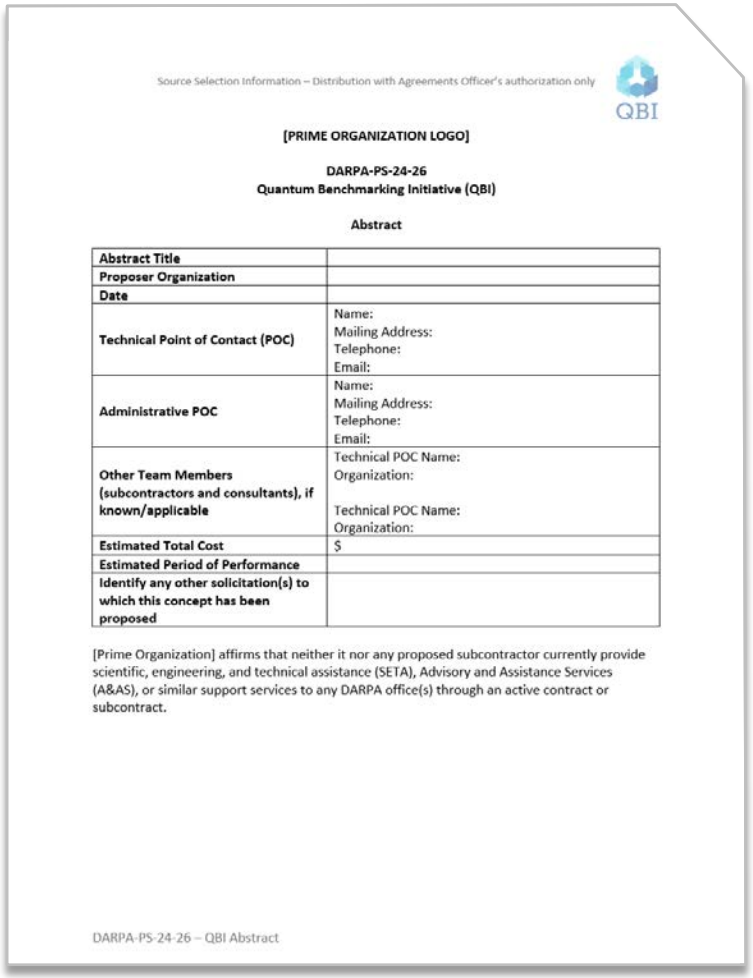


The QBI Program Solicitation – Attachment B

Attachment B – QBI Abstract Template

Document template for your Abstract, including content guidelines

Required with Abstract submission



Source Selection Information – Distribution with Agreements Officer's authorization only

QBI

[PRIME ORGANIZATION LOGO]

DARPA-PS-24-26
Quantum Benchmarking Initiative (QBI)

Abstract

Abstract Title	
Proposer Organization	
Date	
Technical Point of Contact (POC)	Name: Mailing Address: Telephone: Email:
Administrative POC	Name: Mailing Address: Telephone: Email:
Other Team Members (subcontractors and consultants), if known/applicable	Technical POC Name: Organization: Technical POC Name: Organization:
Estimated Total Cost	$
Estimated Period of Performance	
Identify any other solicitation(s) to which this concept has been proposed	

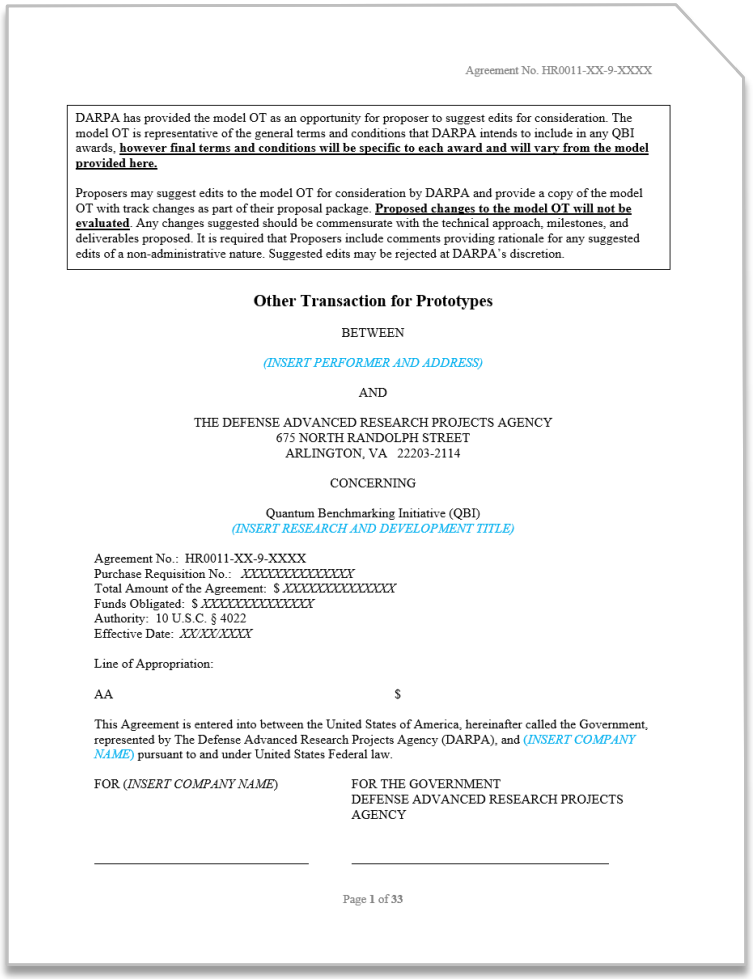
[Prime Organization] affirms that neither it nor any proposed subcontractor currently provide scientific, engineering, and technical assistance (SETA), Advisory and Assistance Services (A&AS), or similar support services to any DARPA office(s) through an active contract or subcontract.

DARPA-PS-24-26 – QBI Abstract

Attachment C – QBI Model Other Transaction for Prototype

Model document for the terms and conditions that DARPA intends to include in any QBI award

Information for proposer use in submitting an Abstract



Agreement No. HR0011-XX-9-XXXX

DARPA has provided the model OT as an opportunity for proposer to suggest edits for consideration. The model OT is representative of the general terms and conditions that DARPA intends to include in any QBI awards, **however final terms and conditions will be specific to each award and will vary from the model provided here.**

Proposers may suggest edits to the model OT for consideration by DARPA and provide a copy of the model OT with track changes as part of their proposal package. **Proposed changes to the model OT will not be evaluated**. Any changes suggested should be commensurate with the technical approach, milestones, and deliverables proposed. It is required that Proposers include comments providing rationale for any suggested edits of a non-administrative nature. Suggested edits may be rejected at DARPA's discretion.

Other Transaction for Prototypes

BETWEEN

(INSERT PERFORMER AND ADDRESS)

AND

THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
675 NORTH RANDOLPH STREET
ARLINGTON, VA 22203-2114

CONCERNING

Quantum Benchmarking Initiative (QBI)
(INSERT RESEARCH AND DEVELOPMENT TITLE)

Agreement No.: HR0011-XX-9-XXXX
Purchase Requisition No.: *XXXXXXXXXXXXX*
Total Amount of the Agreement: $ *XXXXXXXXXXXXX*
Funds Obligated: $ *XXXXXXXXXXXXX*
Authority: 10 U.S.C. § 4022
Effective Date: *XX/XX/XXXX*

Line of Appropriation:

AA $

This Agreement is entered into between the United States of America, hereinafter called the Government, represented by The Defense Advanced Research Projects Agency (DARPA), and (*INSERT COMPANY NAME*) pursuant to and under United States Federal law.

FOR (*INSERT COMPANY NAME*)

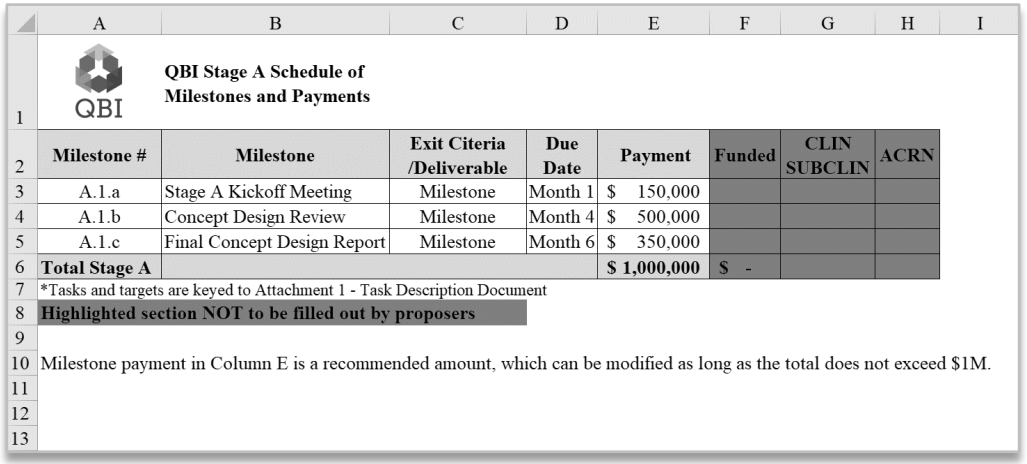
FOR THE GOVERNMENT
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Page 1 of 33

Attachment D – QBI Stage A Schedule of Milestones and Payments

Spreadsheet containing strongly recommended Milestones and Payments for Stage A efforts

Information for proposer use in submitting an Abstract



QBI

QBI Stage A Schedule of Milestones and Payments

Milestone #	Milestone	Exit Citeria /Deliverable	Due Date	Payment	Funded	CLIN SUBCLIN	ACRN
A.1.a	Stage A Kickoff Meeting	Milestone	Month 1	$ 150,000			
A.1.b	Concept Design Review	Milestone	Month 4	$ 500,000			
A.1.c	Final Concept Design Report	Milestone	Month 6	$ 350,000			
Total Stage A				**$ 1,000,000**	$ -		

*Tasks and targets are keyed to Attachment 1 - Task Description Document

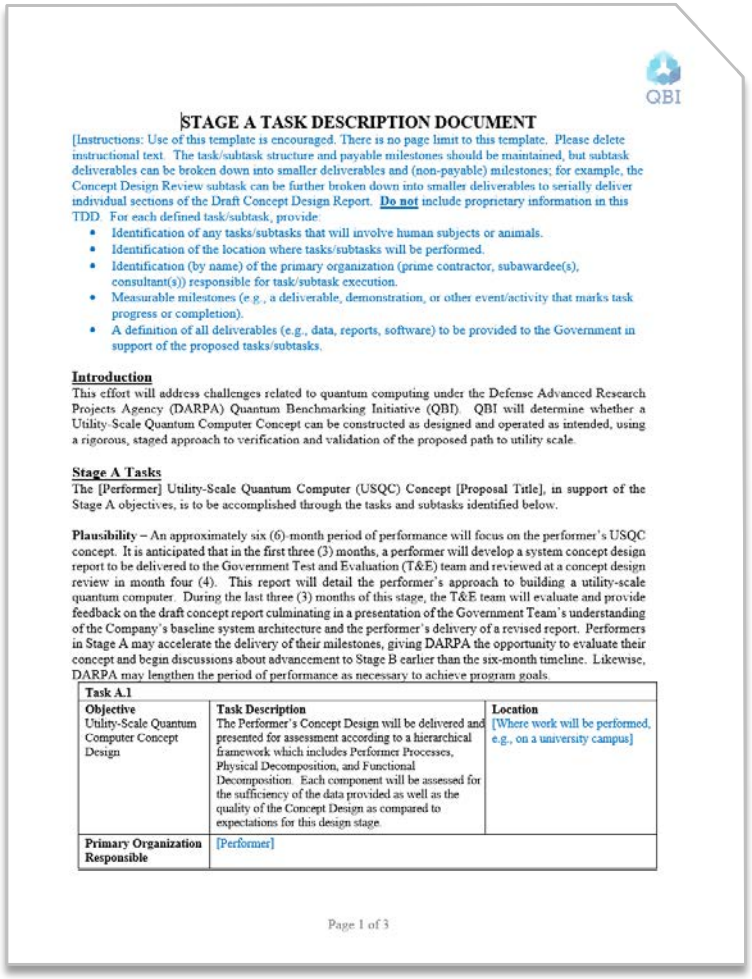
Highlighted section NOT to be filled out by proposers

Milestone payment in Column E is a recommended amount, which can be modified as long as the total does not exceed $1M.

Attachment E – QBI Stage A Task Description Document (TDD)

Template for TDD document outlining the project tasks to be performed along with schedule milestones and delivery dates required for successful completion

Information for proposer use in submitting an Abstract



QBI

STAGE A TASK DESCRIPTION DOCUMENT

[Instructions: Use of this template is encouraged. There is no page limit to this template. Please delete instructional text. The task/subtask structure and payable milestones should be maintained, but subtask deliverables can be broken down into smaller deliverables and (non-payable) milestones; for example, the Concept Design Review subtask can be further broken down into smaller deliverables to serially deliver individual sections of the Draft Concept Design Report. **Do not** include proprietary information in this TDD. For each defined task/subtask, provide:

- Identification of any tasks/subtasks that will involve human subjects or animals.
- Identification of the location where tasks/subtasks will be performed.
- Identification (by name) of the primary organization (prime contractor, subawardee(s), consultant(s)) responsible for task/subtask execution.
- Measurable milestones (e.g., a deliverable, demonstration, or other event/activity that marks task progress or completion).
- A definition of all deliverables (e.g., data, reports, software) to be provided to the Government in support of the proposed tasks/subtasks.

Introduction

This effort will address challenges related to quantum computing under the Defense Advanced Research Projects Agency (DARPA) Quantum Benchmarking Initiative (QBI). QBI will determine whether a Utility-Scale Quantum Computer Concept can be constructed as designed and operated as intended, using a rigorous, staged approach to verification and validation of the proposed path to utility scale.

Stage A Tasks

The [Performer] Utility-Scale Quantum Computer (USQC) Concept [Proposal Title], in support of the Stage A objectives, is to be accomplished through the tasks and subtasks identified below.

Plausibility – An approximately six (6)-month period of performance will focus on the performer's USQC concept. It is anticipated that in the first three (3) months, a performer will develop a system concept design report to be delivered to the Government Test and Evaluation (T&E) team and reviewed at a concept design review in month four (4). This report will detail the performer's approach to building a utility-scale quantum computer. During the last three (3) months of this stage, the T&E team will evaluate and provide feedback on the draft concept report culminating in a presentation of the Government Team's understanding of the Company's baseline system architecture and the performer's delivery of a revised report. Performers in Stage A may accelerate the delivery of their milestones, giving DARPA the opportunity to evaluate their concept and begin discusssions about advancement to Stage B earlier than the six-month timeline. Likewise, DARPA may lengthen the period of performance as necessary to achieve program goals.

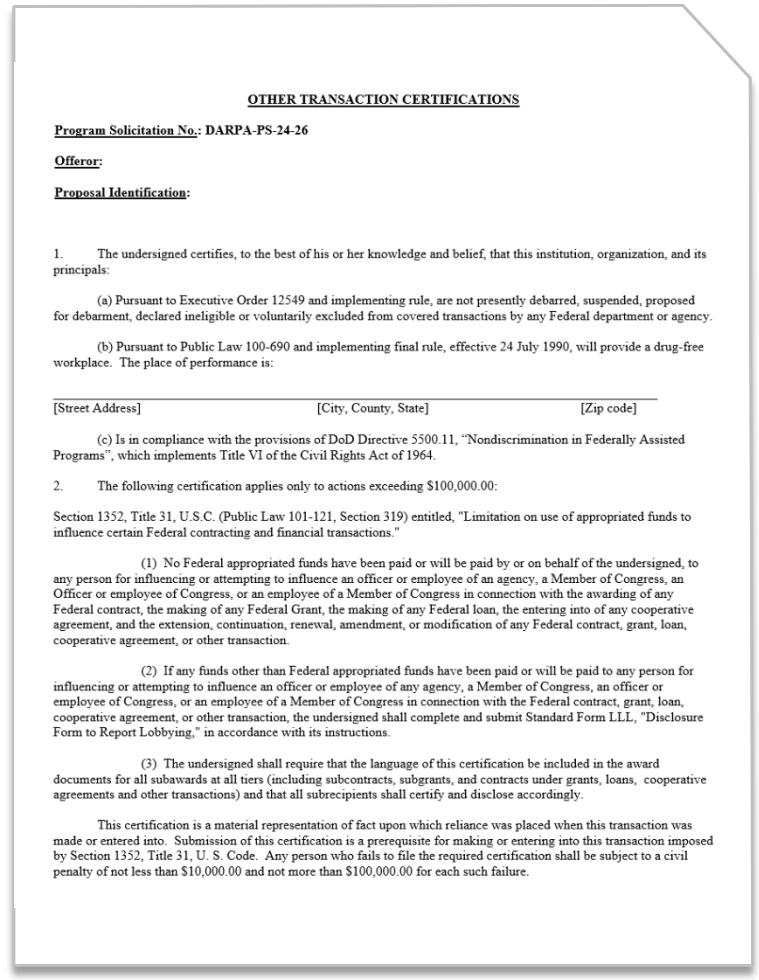
Task A.1		
Objective Utility-Scale Quantum Computer Concept Design	**Task Description** The Performer's Concept Design will be delivered and presented for assessment according to a hierarchical framework which includes Performer Processes, Physical Decomposition, and Functional Decomposition. Each component will be assessed for the sufficiency of the data provided as well as the quality of the Concept Design as compared to expectations for this design stage.	**Location** [Where work will be performed, e.g., on a university campus]
Primary Organization Responsible	[Performer]	

Page 1 of 3

Attachment F – QBI Certifications for Agreement

Representations and certifications required to execute Other Transactions agreements

Information for proposer use in submitting an Abstract



OTHER TRANSACTION CERTIFICATIONS

Program Solicitation No.: DARPA-PS-24-26

Offeror:

Proposal Identification:

1. The undersigned certifies, to the best of his or her knowledge and belief, that this institution, organization, and its principals:

(a) Pursuant to Executive Order 12549 and implementing rule, are not presently debarred, suspended, proposed for debarment, declared ineligible or voluntarily excluded from covered transactions by any Federal department or agency.

(b) Pursuant to Public Law 100-690 and implementing final rule, effective 24 July 1990, will provide a drug-free workplace. The place of performance is:

[Street Address] [City, County, State] [Zip code]

(c) Is in compliance with the provisions of DoD Directive 5500.11, "Nondiscrimination in Federally Assisted Programs", which implements Title VI of the Civil Rights Act of 1964.

2. The following certification applies only to actions exceeding $100,000.00:

Section 1352, Title 31, U.S.C. (Public Law 101-121, Section 319) entitled, "Limitation on use of appropriated funds to influence certain Federal contracting and financial transactions."

(1) No Federal appropriated funds have been paid or will be paid by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an Officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal Grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, cooperative agreement, or other transaction.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the Federal contract, grant, loan, cooperative agreement, or other transaction, the undersigned shall complete and submit Standard Form LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

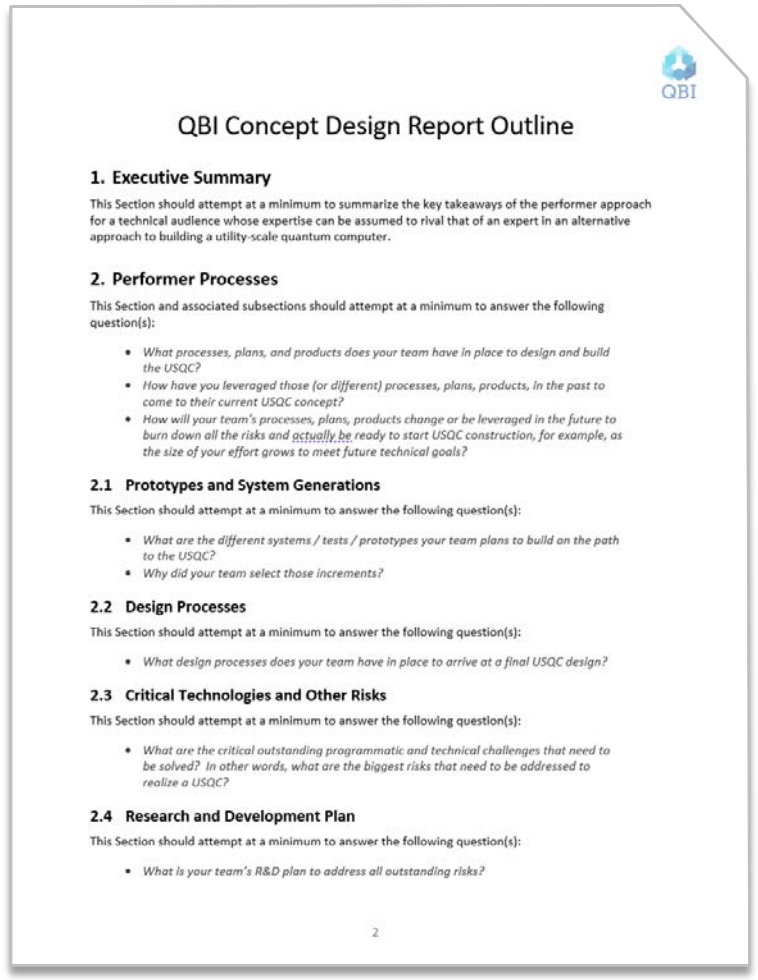
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, cooperative agreements and other transactions) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U. S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000.00 and not more than $100,000.00 for each such failure.

Attachment G – QBI Concept Design Report Outline

Example outline of a Concept Design Final Report, including DARPA's recommended content

Information for proposer use in submitting an Abstract



QBI

QBI Concept Design Report Outline

1. Executive Summary

This Section should attempt at a minimum to summarize the key takeaways of the performer approach for a technical audience whose expertise can be assumed to rival that of an expert in an alternative approach to building a utility-scale quantum computer.

2. Performer Processes

This Section and associated subsections should attempt at a minimum to answer the following question(s):

- *What processes, plans, and products does your team have in place to design and build the USQC?*
- *How have you leveraged those (or different) processes, plans, products, in the past to come to their current USQC concept?*
- *How will your team's processes, plans, products change or be leveraged in the future to burn down all the risks and actually be ready to start USQC construction, for example, as the size of your effort grows to meet future technical goals?*

2.1 Prototypes and System Generations

This Section should attempt at a minimum to answer the following question(s):

- *What are the different systems / tests / prototypes your team plans to build on the path to the USQC?*
- *Why did your team select those increments?*

2.2 Design Processes

This Section should attempt at a minimum to answer the following question(s):

- *What design processes does your team have in place to arrive at a final USQC design?*

2.3 Critical Technologies and Other Risks

This Section should attempt at a minimum to answer the following question(s):

- *What are the critical outstanding programmatic and technical challenges that need to be solved? In other words, what are the biggest risks that need to be addressed to realize a USQC?*

2.4 Research and Development Plan

This Section should attempt at a minimum to answer the following question(s):

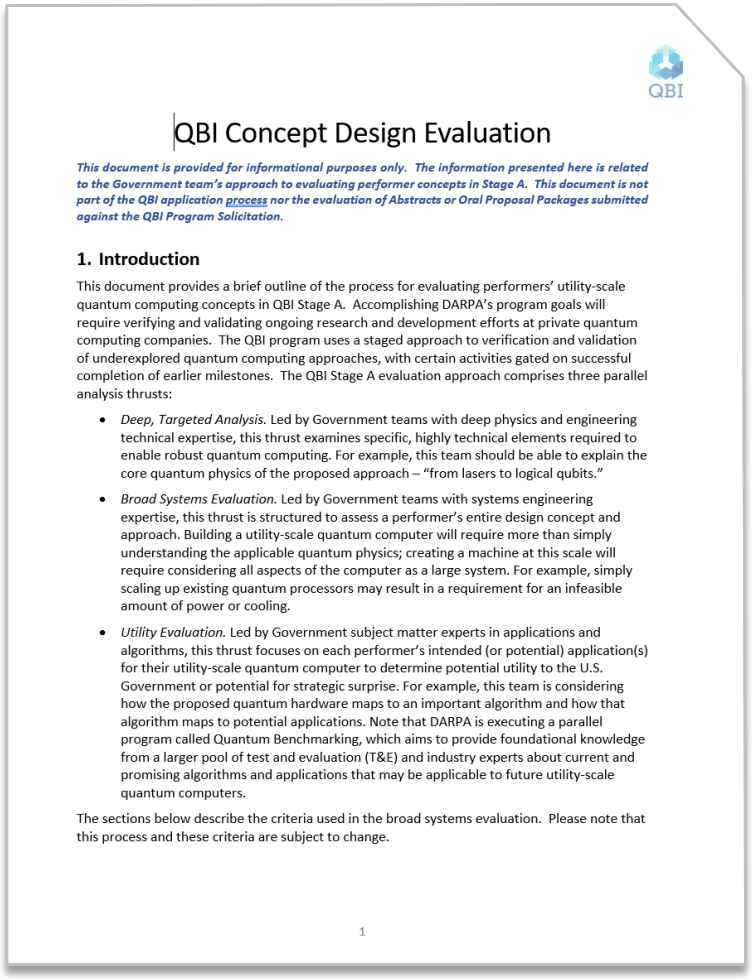
- *What is your team's R&D plan to address all outstanding risks?*

2

Attachment H – QBI Stage A Completion Criteria

A summary of the Government team's approach to evaluating performer concepts in Stage A

Information for proposer use in submitting an Abstract



QBI

QBI Concept Design Evaluation

This document is provided for informational purposes only. The information presented here is related to the Government team's approach to evaluating performer concepts in Stage A. This document is not part of the QBI application process nor the evaluation of Abstracts or Oral Proposal Packages submitted against the QBI Program Solicitation.

1. Introduction

This document provides a brief outline of the process for evaluating performers' utility-scale quantum computing concepts in QBI Stage A. Accomplishing DARPA's program goals will require verifying and validating ongoing research and development efforts at private quantum computing companies. The QBI program uses a staged approach to verification and validation of underexplored quantum computing approaches, with certain activities gated on successful completion of earlier milestones. The QBI Stage A evaluation approach comprises three parallel analysis thrusts:

- *Deep, Targeted Analysis.* Led by Government teams with deep physics and engineering technical expertise, this thrust examines specific, highly technical elements required to enable robust quantum computing. For example, this team should be able to explain the core quantum physics of the proposed approach – "from lasers to logical qubits."
- *Broad Systems Evaluation.* Led by Government teams with systems engineering expertise, this thrust is structured to assess a performer's entire design concept and approach. Building a utility-scale quantum computer will require more than simply understanding the applicable quantum physics; creating a machine at this scale will require considering all aspects of the computer as a large system. For example, simply scaling up existing quantum processors may result in a requirement for an infeasible amount of power or cooling.
- *Utility Evaluation.* Led by Government subject matter experts in applications and algorithms, this thrust focuses on each performer's intended (or potential) application(s) for their utility-scale quantum computer to determine potential utility to the U.S. Government or potential for strategic surprise. For example, this team is considering how the proposed quantum hardware maps to an important algorithm and how that algorithm maps to potential applications. Note that DARPA is executing a parallel program called Quantum Benchmarking, which aims to provide foundational knowledge from a larger pool of test and evaluation (T&E) and industry experts about current and promising algorithms and applications that may be applicable to future utility-scale quantum computers.

The sections below describe the criteria used in the broad systems evaluation. Please note that this process and these criteria are subject to change.

1

Most importantly…

Read the Program Solicitation

(even the fine print)



www.darpa.mil