U.S. DEPARTMENT OF ENERGY | Office of Science

Request for Information: Access to Quantum Systems

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Timeline: Published in Federal Register August 16, 2021; comment period closed September 30, 2021.

Summary: Congress has requested DOE to develop a roadmap to provide researchers access to quantum systems so as to enhance the U.S. quantum research enterprise, stimulate the fledgling U.S. quantum computing industry, educate the future quantum computing workforce, and accelerate advancement of quantum computer capabilities. DOE invited interested parties to provide input on the quantum systems that DOE should include in the roadmap; how the current access models can meet the needs of quantum researchers; and the appropriate timeline and sequencing for components of the roadmap. The Request for Information (RFI) is <u>not</u> an FOA, a Request for Proposal, or other form of solicitation.

Supplementary Information: Input was requested as responses to 12 questions which covered broadly the following:

- Types of quantum systems
- Role of Federal agencies
- Serving a broad community of users
- Access criteria and metrics for success
- Intellectual property provisions
- Other factors, issues, or opportunities

https://www.federalregister.gov/documents/2021/08/16/2021-17520/request-for-information-access-to-quantum-systems

Response Statistics and Information

- **Total Responses:**
  - 23 distinct comments received
  - Published here: https://www.regulations.gov/document/DOE-HQ-2021-0016-0001/comment
- **Labs:** ANL, FNAL (x2), LBNL, ORNL, LLNL, SNL
- **Universities:** Penn State, University of Iowa
- **Companies:** Alpine Quantum Technologies GmBH (Austria), Super.tech Labs Inc., Microsoft, Maybell Quantum Industries, Google, IBM, Deloitte, Quantum Brilliance (Australia), IonQ
- **Other:** Center for Data Innovation, The R Street Institute, CERN, QED-C, Quantum Industry Coalition

General Comments and Overarching Themes

- **Nearly all received comments were responsive to the RFI as published**, though scope, usefulness, and level of detail varied dramatically, and many responses included scope beyond what was requested in the RFI
- **Responses included a mix of perspectives on the need for access to commercial systems and the need to complement that with access to earlier-stage systems not yet ready for commercialization**
- **Responses advocated for an extremely broad range of technologies and platforms to be included**
- **Responses promoted the adoption of useful practices and lessons learned from DOE user facilities**
- **The role of DOE envisioned as more than providing access but offering training programs, internships, support for users, etc.**

1) Types of quantum systems

- **S&T Focus**
  - Computing and simulation
    - Consider different approaches: gate-based, annealing, measurement-based (photons), analog or Hamiltonian simulation
    - Classical simulators
  - Communication/networking
  - Materials synthesis and characterization; device fabrication

- **Technology**
  - Established technologies such as superconducting circuits and trapped ions for gate-based computing
  - Emerging qubit technologies: silicon, photons, neutral atoms, also new types of superconducting qubits and trapped ion systems that may have different capabilities
  - Classical supercomputing
  - The framework for improving access is as important as the specific technologies included

- **Other considerations**
  - Access to a wide variety of different types of systems is important (endorsed in multiple responses, little disagreement)
    - Different users have different needs (size and stability vs. deep access or access to bleeding-edge technology)
    - Commercial systems with clearly defined performance metrics
    - Providing access to *only* cloud-based platforms is inadequate – also need access to smaller, more experimental platforms
    - It's too early to pick winners among technologies
  - Several responses mentioned sensors and supporting technologies (e.g., amplifiers) but did not explain what type of access would be useful

2) Role of Federal agencies

- **Manage an equitable process for community access to centrally-organized resources**
  - Resources should include those at federal facilities or directly funded by the government and government-procured use of third-party resources
- **Ensure that state-of-the-art platforms are available for internal USG research on mission-critical problems**
- **Facilitate training programs (e.g., internships)**
- **Provide skilled staff support to assist users in making best use of accessible resources**
- **Provide support for research using equitable and merit-based funding vehicles**
- **Encourage development of community-defined grand challenges; provide support for addressing them**
- **The government should avoid attempting to centralize all access or restrict freedom of researchers to collaborate**

3) Serving a broad community of users: mechanisms for broad access

- **Types of access**
  - Cloud-based access strongly supported; but access to experimental systems, simulators/emulators and to both software (should be open source) and hardware also emphasized. Adoption of a co-design approach is promoted.
  - Direct user access advocated, but value of having staff assist, implement, or collaborate recognized.
  - Need for information forum, shared data repositories, and gateway to available systems.

- **Administration of access**
  - Conflicting comments or assumptions about who would/should mediate access: DOE, the system providers (lab, commercial, etc.), or some "joint body"

- **Existing and novel models**
  - DOE-SC user facility model and use of CRADAs referenced and supported.

- **Outreach and inclusion, particularly for underrepresented groups**
  - Funded internships were mentioned several times; also visiting faculty support, summer schools, curriculum development, workshops, and other training efforts
  - Specific outreach, partnerships, set-asides for HBCUs, MSIs and EPSCOR
  - Inclusion in review process of criteria related to broadening participation / representation

- **Documentation and training**
  - Make documentation and support info from service providers available. Supplement with training with respect to quantum use-cases. Detailed information on both hardware and software.
  - Public resources, vendor training sufficient for sophisticated users; vendors handle troubleshooting.

4) Access criteria and metrics for success

- **Impact**
  - Scientific success: publications; grand challenges, high-impact publications; presentations
  - Technological success: IP generated; real-world applications; commercialization; industrial growth and use
  - Educational/workforce success: workforce growth / trainees; PhD thesis production; new user groups
  - Access criteria: expected scientific impact; expected technological/societal impact; topical diversity; novelty

- **Users/people**
  - Quantitative success: number of users; usage rate and time used; number of proposals and executed projects
  - Qualitative success: diversity of users, institutions, topics; user experience reflected in responses to surveys; engagement of users and developers who are new to quantum
  - Research access criteria: expertise of proposing team; diversity (in all aspects) of users and workforce
  - Educational access criteria: multidisciplinary engagement, students supported, URM engagement, growth in key skills

- **Resources/systems**
  - Systems success: capacity and capability; diversity of technologies; facility fidelity, reliability, and availability; timeliness of access; wide availability to researchers and proposals; ecosystem growth
  - Access criteria:
    - resources and time needed for proposed project
    - necessity of quantum system for project
    - feasibility (e.g., within error rates) and readiness of proposed project
    - executability of proposed application on proposed platform

- **Annual report to assess metrics for success and update planning as needed**

5) Intellectual property provisions

- **Ownership of IP: Split of comments**
  - Some felt users should keep their IP, unless work was collaborative with the (government or other) service providers, in which case shared IP rights might be appropriate
  - Others argued that commercial organizations (not clear whether this was as users, as system providers, or both) should be able to protect IP developed with their funds, but that IP developed with government funds should be placed in the public domain

- **Models and mechanisms**
  - Comments varied, with several noting that flexibility is key; different models and mechanisms may be suitable for different quantum system hosts and funding entities
  - Existing IP models including user facility agreements and CRADAs (with pre-negotiated language) were recommended where appropriate, but consideration of new models was also suggested.
  - NDAs were mentioned as another potential tool for IP protection.
  - Other comments, that seemed to presume that the systems being accessed would be those of private companies, argued that no standard IP provisions were needed. They advocated that those companies should define IP provisions and that researchers then select systems to use that meet their needs and have acceptable IP provisions.
  - For software in particular, several comments advocated open-source licenses

6) Other factors, issues, or opportunities

- **U.S. security and international competitiveness is a key theme of the comments**
  - Robust and graded security requirements
  - Need for predictable, stable supply chains, preferably domestic
    - Assuring domestic QIS capabilities through U.S. vendors, U.S.-based infrastructure
    - Critical minerals, cryogenics, isotopes
    - Transduction for qubit systems, heterogeneous qubit types
  - Federal investment in industry, including SBIR/STTR

- **Strategic international cooperation with allies is a related key theme**
  - Identify opportunities to establish quantum cooperation agreements with allies
  - For supply chain considerations and for access to R&D
  - Collaboration, export control, usage of foreign S&T

- **Ancillary needs, constraints, suggestions**
  - Inclusion of historically under-represented communities in the planning process
  - Avoid the restriction imposed for most currently available systems that comparative results may not be published without approval by service provider
  - Educational programs in conjunction with hardware/software vendors, academic departments
  - Prioritize algorithm development to address present paucity, and/or focus on NISQ efforts

Next Steps

Activity	Timeframe
Presentation to ASCAC	March 30th, 2022
Develop a draft roadmap (SC Task Force and SC QIS Committee)	Spring 2022
Gather feedback from NQCO and interagency partners	Summer 2022
Present the final roadmap to ASCAC	September 2022