R Street

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Deputy Director Harriet Kung
Office of Science
U.S. Department of Energy
Washington, D.C.

Dear Deputy Director Harriet Kung,

On behalf of the R Street Institute's (RSI) Quantum User Expansion for Science and Technology (QUEST) Coalition, we are pleased to submit the following response per the Department of Energy's (DOE) Request for Information: Access to Quantum Systems (86 FR 45715). The RSI QUEST Coalition respectfully requests that DOE prioritize the advancement of quantum systems by investing in quantum system research and development (R&D), facilitating market competition and furthering near-term applications of quantum computing technology.

Below, please find more detailed information in response to DOE's request.

**(i) What role, if any, should Federal agencies play in mediating, facilitating, or coordinating access to non-Federal quantum systems?**

- Federal agencies need to facilitate and advance quantum computing system development across both hardware and software. As such, the U.S. government should not compete with, but rather scale its investments in near-term, commercially available quantum computing applications. By investing in private sector market growth and engaging in public-private partnerships, the U.S. government will enable R&D for longer term use cases and increase resiliency in public sector priority areas.
- In particular, the U.S. government should implement the Quantum User Expansion for Science and Technology (QUEST) Act if it is passed by Congress in such a way that it creates competition in the marketplace by helping researchers buy time on quantum machines. Research funded through a QUEST program should be mandated to utilize quantum and quantum hybrid technologies, and any research which does not utilize quantum systems should be deemed outside the scope of this program.
- Should the QUEST Act not be passed in the near future, federal agencies should prioritize new quantum computing initiatives using existing research and development funds, including creating a "quantum sandbox" or "research cloud" to allow government agencies and non-governmental entities to access quantum computing systems.

- Agencies should also consider reallocating or reprogramming existing federal funds to create one or more “grand challenges,” calling on private-sector companies to compete and solve complex problems that only quantum computers can tackle, especially in areas such as defense planning, autonomous transportation, sustainable energy, drug discovery and cybersecurity.

**(ii) What special considerations, if any, should be taken into account in accommodating the scientific communities served by these quantum systems?**

- Quantum computing system development is still in its early stages, also known as noisy intermediate-scale quantum technology (NISQ). NISQ technology accounts for quantum systems that have imperfections, or noise, and therefore, are limited in their function for the time being. Even so, investing in NISQ technology is critical for longer term use cases of current quantum technologies and near-term commercial market growth.
- Inclusivity of different hardware and software systems is important to ensure any program can accommodate diverse research needs. Each system may be better equipped for solving specific problems and ensuring a wide variety of systems are available for research will ensure that a researcher is able to utilize the best system for their specific area of focus.

**(iii) What quantum systems should be included in this roadmap?**

- The roadmap should include as many quantum computing systems as possible, as they are all interconnected and essential for critical infrastructure security. Current and projected quantum applications will impact the following sectors: defense, homeland security, healthcare, manufacturing, transportation, financial services, emergency response, and grid and communications resiliency, among others.
- The readiness level of systems should also be a factor in determining what systems are added to a roadmap and when. Quantum computing systems may be more mature than other quantum systems and therefore should definitively be included into any roadmap.

**(iv) What mechanisms should be considered to assure access to quantum systems to the broadest possible user base including under-represented institutions and populations?**

- The U.S. government should support R&D that aligns with state and local economic development goals in conjunction with universities, local businesses, and state and local governments. A diverse workforce in quantum system engineering and development is similarly critical to ensure the inclusion of minority, low-income and underrepresented perspectives.

Further, cloud access, where appropriate, will enable efficient information sharing and resource distribution.

- The U.S. government should also support cloud access to systems, where appropriate, to enable the broadest possible access to quantum systems.

**(v) What are the needs for user support to make effective use of access to quantum systems?**

- Quantum computing systems are interdisciplinary in nature as they are designed to impact nearly every industry, including chip manufacturing, electrical engineering, pharmaceutical drug optimization and algorithmic development. Effective use of access requires cross disciplinary programs and studies, particularly in academic programs, to enable proper workforce development. Federal agencies need to provide a pathway for curriculum development and training on a wide variety of quantum computing hardware and software.

**(vi) What should be the metrics for success in an access model?**

- Federal agencies should produce an annual report with both quantitative and qualitative metrics. Suggested metrics to consider:
    - The number of university-based researchers—determined by geographic location, university type and researcher demographics—using quantum systems to ensure the representation of underserved communities;
    - The number of applications developed and deployed;
    - The number of grand challenges and their results;
    - Students engaged in a robust internship program focused on quantum computing, including one established through public-private partnerships;
    - The number of new technologies added to the program; and
    - Curriculum development and workshops to provide needed workforce development and training.

**(vii) How should software access be provided in conjunction with hardware access?**

- While some quantum computers can be hardware-agnostic and therefore compatible with software designed to work on multiple quantum computers, many companies have utilized proprietary software development kits (SDKs). Between the restrictions of SDKs and existing NISQ technology limitations, developers must have substantial technical knowledge of quantum chip architecture before developing compatible software. In that case, especially in the near term, compatible hardware and software access must be accounted for to support and scale quantum systems R&D.

**(viii) For competitive proposals requesting access to quantum systems, what should be the criteria in the merit review process?**

- Any efforts that will advance near-term applications of quantum systems should be encouraged, especially in solving practical and not strictly theoretical problems facing government, industry, and other sectors today or in the near future. Such areas could include infrastructure, sustainability, energy grid resilience, emergency response, etc. Proposals seeking to maximize quantum hardware and software compatibility and performance and improve quantum error correction (QEC) reliability should take priority.

**(ix) What factors should be considered in adding, expanding, or reducing access to specific quantum systems as the field evolves or matures?**

- The annual reporting and review process, mentioned above, will assess readiness levels, generate recommendations of the incorporation of new technologies, and therefore remove older and more antiquated systems. Further, not every industry focus area will require a quantum processing unit, so hybrid solutions should also be considered. However, to ensure quantum industry is the focus of a quantum government program, there should be a mandate that all projects must utilize quantum systems, and those research projects which are inspired by, but do not utilize quantum, would be deemed outside the scope of QUEST and other quantum-focused programs.

**(x) With respect to access to various types of quantum systems, how do near-term and longer-term priorities differ?**

- Much like Moore's law, Harmut Neven's law predicts that each additional qubit will exponentially increase a quantum computer's speed. If we are to keep up with and stay ahead of quantum's exponential growth, near-term priorities must include federal investment in and benchmarking of quantum computing technologies, despite their imperfections. Federal agencies need to track and compare the variety of quantum hardware and software performance when applied to various use cases, in order to optimize development across industry focus areas.

- Near-term applications development also provides a continuous feedback loop to creation of new applications, new materials and hardware advancements; therefore, the government must have a focus on what can be developed and deployed with the technology within the next five years along with a longer-term more foundational research approach. Moreover, near-term applications created via a QUEST program would establish the United States as a global leader of both quantum computing systems but also export of quantum applications.
- However, we also need to be preparing for long-term challenges today, including ensuring the U.S. government provides incentive to public and private sector stakeholders to apply post-quantum cryptography standards as early as possible to begin safeguarding information which could later be put at risk by advanced quantum computing systems.

**(xi) What standard intellectual property (IP) provisions are needed to facilitate broad access to quantum systems for the public benefit?**

- Private sector companies should be able to define the scope of their own intellectual property provisions, with researchers selecting access to the systems which best meet their needs and where IP provisions are acceptable. Given that most technological companies are crafting their own SDKs in quantum computing development, private-sector IP provisions—including patent, trademark and copyright protections—are important to many technology companies in order for them to partner with researchers confidently and take their products to market, knowing they will see a return on investment.

**(xii) Are there other factors, issues, or opportunities, not addressed by the questions above, which should be considered in the development of such a roadmap?**

- The quantum industry relies on the global supply chain of critical minerals and even cryogenics. Therefore, we must ensure the United States engages in expanded quantum cooperation agreements with key allies around the world, especially with the Five Eyes, to build on the 2019 U.S.-Japan agreement. Cross-border research and innovation is critical to ensure the United States maintains its competitive advantage, a robust supply chain and access to important research developments. Partnerships with key allies who have robust quantum work in Canada, United Kingdom, European Union, Australia and others would be extremely helpful in cross-border collaboration and boosting supply chain confidence.
- It cannot be emphasized enough that a roadmap should explore any and all opportunities to increase federal investment in the nascent U.S. quantum computing industry using existing

authorities and resources, independent of future congressional appropriations. It is imperative that the United States remain in the lead in this emerging technology space, and our success in doing so will depend on real public-private partnerships focused on increasing choice and competition in the quantum computing marketplace and incentivizing user access and the creation of near-term applications.

Respectfully,

Miles Taylor
Senior Fellow, Cybersecurity and Emerging Threats
The R Street Institute