A Public Meeting of the

National Quantum Initiative Advisory Committee (NQIAC)

August 6, 2024

Meeting Minutes

MEETING PARTICIPANTS

Committee Members (in attendance)

- Gretchen K. Campbell, Co-Chair
- Kathryn Ann Moler, Co-Chair
- Jamil Abo-Shaeer
- Fred Chong
- James S. Clarke
- Deborah Ann Frincke
- Gilbert V. Herrera
- Nadya Mason
- William D. Oliver
- John Preskill
- Mark B. Ritter
- Robert J. Schoelkopf
- Krysta M. Svore
- Jinliu Wang
- Jun Ye

National Quantum Coordination Office Staff Supporting the NQIAC

- Gretchen K. Campbell, Director
- Brad Blakestad, Deputy Director
- Tanner J. Crowder, Senior Policy Advisor and NQIAC Designated Federal Officer (DFO)
- Thomas G. Wong, Consultant

Invited Speakers

- Asad Ramzanali, Office of Science and Technology Policy

Public Speakers

- Leland Cogliani

START DATE AND TIME: Tuesday, August 6, 2024 at 1:00 PM Eastern Time

LOCATION: Eisenhower Executive Office Building, Washington, DC, and virtually via Zoom for Government

OPENING

As the Designated Federal Officer, Crowder welcomed the NQIAC (or "the Committee"). Co-Chair Moler opened by thanking everyone for their work, especially the NQIAC Subcommittee on Quantum Networking ("the Subcommittee"). She also welcomed Campbell as the new Co-Chair of the Committee. Campbell welcomed the NQIAC back to the White House. Campbell thanked Charlie Tahan for his previous work as Co-Chair, as well as Crowder, Wong, and the Science and Technology Policy Institute (STPI) for their work.

Campbell introduced Ramzanali, Special Assistant to the President, and Deputy Director for Policy and Chief of Staff at the White House Office of Science and Technology Policy, to speak. Ramzanali congratulated Campbell on her new role and thanked everyone for their efforts. He said one of his favorite quotes from President Biden is that America, in one word, is "possibility." Ramzanali said he thinks science and technology helps turn possibility into reality. He added that it is important to be at the leading edge of technology. Ramzanali also stressed the importance of being inclusive, considering who has access to technology and who is involved in conversations about technologies. This includes investing in institutional capacity at historically Black colleges and universities and Tribal colleges and universities, which Ramzanali considered especially important as the National Quantum Initiative (NQI) comes up for reauthorization. Ramzanali closed by stressing the importance of having the best expertise to inform policy and thanked the NQIAC for their critical role.

PUBLIC COMMENT

Two members of the public submitted requests to make oral comments in advance of the meeting, but one did not show up. Cogliani, in virtual attendance, presented his comment. He thanked the NQIAC for advancing leadership in quantum technologies and recommended continued scale-up of Department of Energy Office of Science investments in quantum information science (QIS), including quantum networking. He noted that the House of Representatives NQI reauthorization also included greater support for quantum networking.

QUANTUM NETWORKING FINDINGS AND RECOMMENDATIONS

Ritter, Co-Chair of the Subcommittee, introduced the Subcommittee's preparatory findings and recommendations for deliberation for the full committee, which were presented as slides.[1] Discussion began with an overview of the Subcommittee's six findings. Ritter read Finding 1. He noted that the Subcommittee had a long discussion, and some applications of quantum networking were well understood while others were not. Ritter stressed that quantum networking will not fully replace classical networking, just like quantum computing will not fully replace classical computing. By enabling

[1] All slides presented are available in full online: https://www.quantum.gov/wp-content/uploads/2024/09/NQIAC-Slides-2024-08-06-Draft.pdf

the distribution of quantum states or sharing of entanglement, quantum networking will provide new resources.

Svore, the other Co-Chair of the Subcommittee, read Finding 2 and highlighted the need to continue funding research and development in quantum networking, in particular to better understand the variety of applications in the field. She noted that there are still questions about what quantum advantage looks like in quantum networking. Ritter read Finding 3 and noted that devices developed for quantum networking will likely be useful in other areas. Svore read Finding 4 and noted that the term "testbed" is ambiguously used, with many stakeholders using the word in different ways. Ritter read Finding 5, pointing out that while early quantum networking systems exist, the impact is not yet clear. Svore read Finding 6, noting that testbeds have historically played a role for emerging technologies to move to market and the Subommittee identified a need for testbeds in quantum networking.

Regarding Finding 1, Chong asked if the NQIAC wanted to encourage more coordination between other NQI efforts and activities in quantum networking. Preskill noted that is it helpful to account for different distance scales when thinking about applications of quantum networking, which can connect to other topics like quantum computing, sensing, and encryption. Moler asked if the Subcommittee had considered quantum key distribution (QKD) in light of the National Security Agency's (NSA) statement that post-quantum cryptography is more cost-effective than QKD. Frincke pointed out that NSA's statement was not meant to discourage QKD research but was meant to reflect cost- and time-effectiveness in the near-term. Herrera noted there are current use cases for QKD and a testbed is a way for people to understand vulnerabilities. Preskill added that future research into QKD could address the NSA's concerns. Herrera also clarified that in QKD, the encrypted data itself is not protected by the laws of physics as some descriptions suggest. The distribution of the encryption key is protected by the laws of physics and the data is merely protected by classical encryption using the quantum-protected key.

On Finding 6, Mason said the finding does not mention how testbeds are specifically necessary for quantum networking. Based on the Subcommittee's conversations with experts, Svore stated how exactly testbeds are necessary is an open question. This is why testbeds will need to have the right scope and be set up at the right time. Svore said the Subcommittee is open to perspectives on this. Chong pointed out that while the timing might be open, the finding was unclear about why the Subcommittee wants the United States to build testbeds. Ritter responded that researchers will realize what else they need to understand as they start to bring technologies together in testbeds.

Ye asked if it would be useful for Finding 6 to discuss who is solving technologically difficult problems in areas like transduction and repeaters. He noted that most people are building dark fiber networks. Ritter mentioned that some people said their organization had a testbed when it should really be considered a demonstrator. Ye outlined three purposes he saw for testbeds: training students, testing components, or grand challenges like imaging black holes or solving problems related to quantum gravity.

Herrera initially thought about Department of Energy user facilities and thought it would be helpful to add more to the finding about how industry use is a key characteristic of testbeds. Ritter said there could be more on this in a full report on the findings and recommendations. Mason noted that it is important for testbeds to leave room open for scientific exploration. Deborah Frincke added that a nice outcome of some testbeds is the tendency for user communities to form around and commit to updating them. Moler agreed with Herrera's distinction between user facilities and testbeds, with user facilities focusing on early-stage research.

There were no comments from NQIAC on Findings 2, 3, 4, and 5.

Svore and Ritter alternated reading all seven of the recommendations from the slides. After Recommendation 1, Svore said the Subcommittee had only heard a handful of quantum networking applications with advantage from stakeholder meetings and there is a need to conduct research into the advancement potential applications. Reading Recommendation 2, Ritter noted that metrics are becoming their own discipline within the broader field of QIS. After reading Recommendation 3, Svore stressed that funding should be allocated when testbeds are both "right-sized," defined as appropriate in scope and scale, and "properly-timed," defined as when the technology is mature enough. After reading Recommendation 4, Ritter pointed out that quantum networks will require both classical and quantum components, and the community will need to begin thinking about the interaction between these technologies. Svore read Recommendation 5 and noted that industry knowledge on operations, security, and customer needs will be needed to determine the right size for testbeds. Ritter read Recommendation 6 and mentioned that other countries were working on quantum networking before the NQI was established and that researchers should be encouraged to collaborate internationally if it benefits them.

After a break, Crowder reminded the audience there is a process to submit public comments in advance, so no comments or questions would be taken from non-NQIAC members virtually attending the webinar.

The NQIAC proceeded to discuss the recommendations from the slides. Clarke asked how they compared to the Committee's recommendations from last year's report. He noted that last year's recommendation was for increased funding, and it sounded like the call was now to continue funding. Based on consideration of funding in other areas of QIS, Svore said the Subcommittee decided to recommend continued support for quantum networking instead of increased support. Ritter noted that Recommendation 6 specifically calls for new funding to support international collaboration. He remarked that the U.S. Government is spending around $500 million on quantum networking, based on the Annual Report on the NQI, and the Subcommittee did not want to suggest more if this would come from other QIS areas.

Ye appreciated Recommendation 2 and its discussion of metrics, which he felt is not often talked about in quantum networking. He liked the discussion of functional layers in Recommendation 4. Ye suggested swapping the order of Recommendations 3 and 4 so the content of Recommendations 2 and 4 would be closer together. Moler supported this, as it would emphasize that Recommendation 3 is dependent on Recommendations 2 and 4.

Mason asked if Recommendation 3 should include language about ensuring testbeds have clear scientific goals, echoing a point a Ye made earlier, or if the Subcommittee thought this was already embedded in the existing language. Svore responded that this is part of "right-sized" testbeds and a report on the findings and recommendations would include text on scientific goals and promise.

Mason asked about what is meant by "like-minded partners" in Recommendation 6. Crowder explained this refers to countries with similar values and research environments. Campbell mentioned this is a common term.

Herrera asked if "goal" or "objective" would be a better term, noting that failure can be acceptable in research. He added this was not necessarily a change he was seeking in the recommendations.

Preskill thought that Recommendation 5, as presented by the Subcommittee Co-Chairs, sounded like industry would direct the conversation about economic impact. However, communication from government to industry is also useful, like technical scrutiny. Svore agreed it is important for communication to be bi-directional between government and industry.

Moler asked to hear more from committee members about the international landscape and how that should impact Recommendation 6. She mentioned that the many academic researchers who attended the events of the National Academies' National Science, Technology, and Security Roundtable now think about security issues. Moler pointed out that researchers can have different reasons for collaborating internationally. Partners can bring different things to the table, and collaborations are important to keeping abreast of research developments in other countries. Ye added that collaborations also bring talent to the United States, which is especially important for the quantum workforce.

Moler noted that quantum collaborations are often stymied when other governments allocate money for international collaboration but the U.S. side cannot commit money, which requires funding through another mechanism. Ritter also knew of academic colleagues who struggled to get grants for international work. This is why the Subcommittee recommended money specifically for international collaboration.

Svore said the Subcommittee had heard of varying purposes for international partnerships. Some are about thought leadership while some are focused on building testbeds. Ritter pointed out that it is easier to work with allies and partners on developing standards if the countries have already been working together on the technology research and development. While Ritter did not think the community is ready to make standards, it is something they will need to think about.

Chong asked about what kind of activity would be covered under the Subcommittee's recommendation. He found it unclear if this funding would just cover international travel for U.S. researchers or if it could fund researchers outside the United States. Ritter responded that the intent of the recommendation is for money that could allow both the U.S. researcher and their international collaborator to be funded. Ritter said a report on the findings and recommendations can clarify this.

Herrera asked how many existing agreements the United States has signed on to. Crowder said there are 11 bilateral cooperation statements, which are technically not agreements. These are very high level and agencies are responsible for determining implementation.

Chong asked if it would be more practical to encourage coordinated funding mechanisms for collaboration with other countries. Ritter said some agencies already do this. Mason mentioned that in other examples she aware of, each researcher had to get funding from their own country.

Preskill noted that while the NQIAC has discussed about the lack of known applications for quantum networking, he thinks this is true in varying degrees for all areas of QIS. He expressed support for Ritter's statement earlier in the meeting that sharing quantum entanglement on a global scale would provide humanity with a new resource. Svore asked if the Committee should change the recommendation. Preskill replied that he thinks his view can be covered in the supporting text of a report on the findings and recommendations, but wants to make sure people do not get the sense that quantum networking is the only QIS discipline where there is concern about limited applications.

Chong asked if the NQIAC could say it has the same optimism for quantum networking as it does for other areas of QIS. Moler said the case for optimism in quantum computing is pretty strong. While

building quantum computers has been hard, she remarked that it has been hard for important reasons. While there is some worry that the only proven advantage is Shor's algorithm, Moler noted that there has not been a new form of computation that has not had a major impact. Herrera pointed out that while the first digital computers were designed for ballistics calculations, they quickly advanced to business applications, and the next military application was command and control.

Svore asked if the Committee thought there were any missing recommendations from those presented.

Moler pointed out that Richard Feynman's first proposal for quantum computers involved using them to simulate quantum systems. She asked Ritter and Svore if they would like to make any guesses about the role of quantum networking in quantum simulation based on what the Subcommittee learned from their interviews with quantum networking stakeholders and experts. Svore replied that certain quantum computing architectures may need distributed quantum computing to reach the necessary number of qubits for simulation. Ritter noted that connecting more qubits through quantum networking will speed up a computer, and this improvement will scale exponentially instead of linearly.

Ritter also said that we do not know what will happen if quantum sensors are connected by quantum links. Ye said this is already happening classically with the imaging of black holes and noted that quantum networking could be important in distributing resources when imaging in photon starved regimes. Svore asked Ye what connecting networks to quantum sensors could enable. Ye said researchers are starting to look at this in the lab by optimizing Greenberger-Horne-Zeilinger (GHZ) states.

Chong asked if clock synchronization and timing came up as topics during the Subcommittee's interviews. Svore replied that they did. Chong pointed out that this could be a potential synergy with quantum computing and sensing. He then asked if the Committee would want to recommend anything about potential synergies and coordination between quantum networking research and other areas of QIS. Svore said the Subcommittee could think about that. Chong suggested it could be a bullet under another recommendation and not a full point on its own. Crowder suggested adding this point under Recommendation 1. Ye suggested this could also go under Recommendation 3.

Regarding the language on "continuing to support" in Recommendation 1, Ye asked that if other QIS areas were to receive more funding, would the Committee want quantum networking to also receive more funding. He was concerned the recommendation's language could be interpreted as suggesting quantum networking should be a lower priority than other QIS areas. Campbell replied that there is a concern about reallocating existing funding. Moler said it would be fair to say that QIS as a whole could use more funding, but quantum networking did not seem to be over- or underfunded relative to other areas. Herrera said that he thinks agencies are still figuring this out. Quantum computing is relevant to every agency. Quantum sensing is relevant to a few agencies, including defense. Herrera believed that quantum networking falls in between: it has broad relevance, but its use is not specific to many agency missions.

Mason asked if the National Laboratories would be mentioned in the text of a report on the findings and recommendations. Svore replied that a report would discuss regional expertise, and they could consider the National Laboratories under that. Frincke said she appreciated this question, as the Subcommittee thought they had considered the National Laboratories and wants to make sure they show up clearly in a report on the findings and recommendations. Moler stated that her understanding is that NQIAC

makes recommendations to all of the Federal Government, but it is not the Committee's place to tell the Department of Energy to do something specifically.

The meeting was adjourned at 2:54 PM Eastern time.

CERTIFICATION

I hereby certify that, to the best of my knowledge, the foregoing minutes are accurate and complete.

Gretchen K. Campbell, PhD
Co-Chair
National Quantum Initiative Advisory Committee

Kathryn Ann Moler, PhD
Co-Chair
National Quantum Initiative Advisory Committee