A Public Meeting of the

National Quantum Initiative Advisory Committee (NQIAC)

March 24, 2023

Meeting Minutes

MEETING PARTICIPANTS

Committee Members

- Kathryn Ann Moler, Co-Chair
- Charles G. Tahan, 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

- Charles G. Tahan, Director
- Gretchen K. Campbell, Deputy Director
- Tanner J. Crowder, Policy Analyst
- Thomas G. Wong, Quantum Liaison and NQIAC Designated Federal Officer (DOE)

Invited Speakers

- Asad Ramzanali, Office of Science and Technology Policy

Public Speakers

- No members of the public presented statements

START DATE AND TIME: Friday, March 24, 2023 at 9:00 AM Eastern Time

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

OPENING

Wong called the meeting to order. Co-chair Tahan introduced himself and provided context on the National Quantum Initiative Advisory Committee (NQIAC), established as a Presidential advisory committee as directed by Congress in the National Quantum Initiative (NQI) Act. The NQIAC is charged with making recommendations for improving the NQI, which was launched nearly five years ago. Tahan shared details of the meeting agenda and introduced co-chair Moler.

Co-chair Moler thanked the NQIAC members, who first met in December 2022, for their hard work to date. She acknowledged and thanked the individuals who met with NQIAC subcommittees over the past few months to answer questions about NQI activities, including individuals from Federal agencies, DOE national laboratories, and others. She also thanked the staff of the National Quantum Coordination Office (NQCO) for their tireless efforts to coordinate NQIAC activities.

The co-chairs then turned the floor over to a presentation of draft findings and recommendations from the NQIAC Science and Infrastructure Subcommittee.

SCIENCE AND INFRASTRUCTURE SUBCOMMITTEE FINDINGS AND RECOMMENDATIONS

Subcommittee co-chairs Mason and Oliver presented details of the subcommittee's process. The subcommittee met weekly to consider the science and infrastructure dimensions of the NQI, including by reviewing NQI-related documents and engaging with experts at quantum information science (QIS) research centers (Centers) and Federal agencies. The co-chairs presented the subcommittee's preliminary draft findings and recommendations on the Centers, the scientific scope of the NQI, collaborations and partnerships, administrative burden, infrastructure, and testbeds, as captured in their slide deck.[1] Moler opened up the floor for full committee comments, feedback, and discussion.

Mason noted that this subcommittee had focused on science and infrastructure, and agreed that there are cross-cutting areas that the NQIAC will want to ensure are not missed in the final report. Schoelkopf added his understanding that the Centers had been catalysts for new collaborations in new research areas—rather than just more of the same.

Clarke introduced the topic of building integrated systems, suggesting that little work is underway, save some in industry, and that there could be an opportunity for the Federal Government in this area. Oliver noted the subcommittee's suggestion that fundamental engineering be an added emphasis for the NQI, given that much of the engineering necessary for integration remains to be developed. Ye agreed that fundamental engineering is important and should be integrated with science in the NQI. Clarke agreed

[1] All slides presented are available in full online: https://www.quantum.gov/wp-content/uploads/2023/03/NQIAC-Slides-2023-03-24-Draft.pdf

that basic science efforts should not be decreased, and suggested that integration efforts could be increased in the next five years, with a role for industry. Svore commented that moving towards engineering will help to accelerate economic impact. Moler suggested that we will not learn which qubit type will scale to a million-qubit quantum computer by funding few-qubit efforts. Preskill highlighted the importance of individual-PI research, including those affiliated with Centers, suggesting that some future progress and advances will come from small labs.

Tahan commented on the range of technologies included in QIS and noted the importance of thinking about near-terms wins and what kinds of outcomes and impacts are feasible in the next five years. Frincke noted that quantum sensors, likely near-term technologies, could be an opportunity to support workforce development efforts. Herrera added that the underlying engineering for quantum sensors is better understood than other areas of QIS and expressed concern that large-scale quantum system engineering is not yet well-understood. Ritter agreed with Herrera that problems cannot be tackled at a large scale at first; in his experience, integration efforts need to start small.

Oliver commented that the group seemed to agree strongly about the importance of seeding engineering efforts. By building larger systems, new science and engineering problems are revealed. Abo-Shaeer suggested that, in the future, quantum technologies will require more engineers than physicists. Moler and Abo-Shaeer noted that Centers can play an important role in building the QIS workforce. Schoelkopf commented that technology is not a one-way transfer from science to engineering to products, and since the United States wishes to lead both in the science and in realizing the economic benefits of quantum information science and technology (QIST), it should consider ways to accelerate the transition to the latter.

Wang proposed a recommendation that all Centers identify community-driven use cases to help identify key technical issues to be solved during the next stage of the NQI. Tahan added that one of the Quantum Frontiers identified in the NQCO's 2020 report is to find use cases, and suggested that this should be a primary goal; known near-term use cases could deliver some needed wins.

The group discussed issues related to infrastructure. Svore asked for more details about "critical path" infrastructure needs, including the cryogenics supply chain. Mason noted that the subcommittee discussed cryogenics and isotope supplies with agency staff, and heard that plans or roadmaps were in place or in progress. Oliver noted the importance of smaller-scale infrastructure and of software. Svore added that a lack of infrastructure impedes industry as well as academia; it can take years to get certain types of equipment. Chong and Ye added that Centers cannot easily acquire components, such as neutral atom sources, for which there are not "plug-and-play" options available as there are for other qubit types. Ritter noted that this means researchers need to build components themselves; companies will invest when they see that there is a business case for doing so. He suggested that the Small Business Administration could play a role, and noted that quantum technologies tend to be expensive.

Mason noted that some center directors pointed to a need for more materials and fabrication capabilities at existing facilities, and for more foundry services. Chong commented that testbeds are also important and can help drive engineering all the way to the device level. Schoelkopf cautioned against establishing large "centralized" infrastructure such as foundries too early around a particular material, business, or process. Oliver agreed that small- and medium-scale infrastructure has advantages. Moler commented that it is hard to know at this time which platforms to advance. Mason said that the subcommittee did not hear a clamoring for large-scale testbeds, reflecting the early state of the fields.

Tahan asked what was needed at a national scale over the next 10 years. Ritter commented that European governments (including the EU and individual nations) have invested a substantial sum in QIS.

The group also discussed the utility of longstanding nanoscience centers for QIS research and development (R&D) and the potential need to refresh and update these facilities; the distinction between foundries, which provide fabrication services, and user facilities, where researchers can go to use a particular tool; the potential need to build out testbeds over the next five years; and the need for fundamental engineering and successful demonstration projects before investing in large-scale infrastructure.

The subcommittee also discussed how best to leverage industry infrastructure. Moler noted that the willingness of industry to provide samples and infrastructure to academia is a strength of the U.S. ecosystem, and pointed to the importance of enabling this, including by protecting industry resources. Oliver noted that U.S. industry has a strong presence in QIS, including startups. He suggested that the group consider how to highlight the impact that government investment has had on building a quantum workforce. Schoelkopf commented that the discussion had centered mostly on government-funded infrastructure under the NQI. He said that substantial industry, private sector, and other university investments are underway in no small part because the NQI has signaled that QIS is a high-level priority.

Preskill commented that the ecosystem also needs ideas and discovery of applications for QIST. The NQIAC believes that QIS will have a great impact in the future, but much remains to be learned about what these technologies will do, especially for quantum computing and networking.

WORKFORCE AND INDUSTRY SUBCOMMITTEE FINDINGS AND RECOMMENDATIONS

Subcommittee co-chairs Wang and Clarke presented details of the subcommittee's process. The subcommittee met weekly and engaged with representatives from the National Q-12 Education Partnership (Q-12), the National Science and Technology Council (NSTC) Subcommittee on Quantum Information Science (SCQIS) Interagency Working Group on Workforce, the Quantum Economic Development Consortium (QED-C), the National Institute of Standards and Technology (NIST), and immigration attorneys. The co-chairs presented the subcommittee's preliminary draft findings and recommendations on workforce and industry dimensions of the NQI, as captured in their slide deck. Moler then moderated full committee discussion.

Mason asked to what extent the subcommittee's workforce recommendations on coordination and leveraging existing fellowships are already occurring. Clarke said that substantial activity exists but full implementation has not yet been realized. Wang added that Q-12 and other NQI workforce activities have been effective, and the subcommittee focused on needs for the next five years.

Chong suggested that QIS could be an appealing topic for recruiting students into STEM more generally, and could help broaden and diversify the workforce. Svore agreed that quantum mechanics can be an inspiration for students, but it can be challenging to incorporate at the K-12 level. Instead of new QIS programs, it would be easier to incorporate key concepts into existing curricula, such as for chemistry. Ritter commented that the space program has been a historical hook for young people to enter STEM because it is easier to grasp than quantum. He asked what examples of real-life QIS applications can be used to attract students. Abo-Shaeer noted that QIS is more than quantum computing. He said 3 million people are impacted by GPS each day, with a trillion dollars of economic impact ultimately enabled by

quantum mechanics and quantum physics. Moler added that while not everyone understands GPS, everyone can appreciate it; people could be surprised to learn that QIS is involved.

NQIAC members discussed ways in which QIS outreach program resources could be consolidated. Svore said that such resources could be managed centrally as a resource for primary investigators (PIs) rather than being recreated in isolation by QIS PIs at every institution. Tahan added that the Q-12 program is a National Science Foundation (NSF) sponsored project with several PIs and a near-term focus that could be complemented by a new center focused on outreach, education, and long-term activity. Wang added that NQIAC recommendations should aim for a commitment to workforce development that lasts longer than five years. Mason commented that not every PI needs to reinvent their program, but all PIs should consider outreach as part of their research.

Frincke commented that a 5- to 10-year gap between aspiration and workforce readiness may not be enough to bridge a "quantum winter" and "valley of death." Frincke and Moler raised the issue of how to decide which efforts to support. Clarke noted that the valley of death is not unique to QIS, and he and Herrera emphasized the importance of finding applications to bring revenue to the quantum industry. Herrera suggested that progress does not necessarily occur in a straight line, but rather as an iterative spiral between research and market.

Mason noted that the Science and Infrastructure Subcommittee heard that some government policies and regulations inhibited collaboration across sectors. She asked whether the Workforce and Industry Subcommittee found this as well, and whether agreements, procurements, or audits inhibited industry participation. Abo-Shaeer and Clarke suggested that even when leveraging resources of the national laboratories, it can take six months or more for the paperwork to collaborate to be signed. NQIAC members discussed how the U.S. government might streamline processes that support collaboration with industry.

Herrera commented that intellectual property (IP) concerns can pose both security issues and challenges for technology transfer, and suggested that the subcommittee consider ideas for improving partnerships with industry in government-sponsored research. He asked if the subcommittee heard from potential funders of quantum startups such as In-Q-Tel. Wang said no, and noted that quantum startups must demonstrate commercial value and viable business model with clearly defined use cases to secure large amounts of funding.

Svore suggested that industry has played a relatively small role in NQI activities, and that the subcommittee's recommendations focus on potential industry roles. Schoelkopf suggested that the next phase of the NQI should identify specific challenges for industry to support partnerships to achieve economic benefits for the nation. Herrera noted use cases are needed to support commercialization. Frincke suggested that cyber industry could serve as a model for the QIS industry to consider. Abo-Shaeer commented that cross-skilling is a resource to capture an untapped workforce into the QIS field.

REMARKS, ASAD RAMZANALI

Asad Ramzanali, OSTP Chief of Staff, thanked the NQIAC members for their service, noting that policymaking is only as good as the brains around the table. He said that the President says, "Show me your budget, and I'll tell you your values," and noted that the current budget request for science is the highest ever. He described OSTP Director Dr. Arati Prabhakar's view that science and technology is critical for achieving the country's aspirations. He said that much of today's technology was built in the

20th century, and that quantum science has fed into much of today's technologies, which are critical to where we are. Where quantum science will take technology next is hard to say.

Ramzanali said that, as the NQIAC conducts its assessment of the NQI, it will be important for OSTP to hear what the group is learning and how to build on the efforts already underway. He pointed to the provisions supporting QIS R&D in the recent CHIPS and Science Act as an illustration of how QIS activities are not siloed. The group's expertise on QIS and input on what is needed in each of the six thematic areas of the NQI will be very important. He thanked the group again for their efforts and contributions.

SECURITY AND INTERNATIONAL SUBCOMMITTEE FINDINGS AND RECOMMENDATIONS

Subcommittee co-chair Preskill presented the work of the Security and International Subcommittee. The subcommittee was tasked with assessing the security and international aspects of the National Quantum Initiative and making recommendations about how they could be improved. They received briefings from government officials about technology controls, the migration to post-quantum encryption, foreign students in QIS, the Committee on Foreign Investment in the United States, and the NSTC Subcommittee on the Economic and Security Implications of Quantum Science (ESIX). The subcommittee discussed how best to balance the risks posed by advanced QIS technologies with the benefits such technologies might provide in many fields, including metrology, sensing, and computation. Preskill invited subcommittee co-chair Herrera to share remarks. Herrera noted that he could not help but make an observation about the global nature of talent, and noted that members of the NQIAC or their parents may have been immigrants to the United States. Following the presentation, NQIAC members discussed subcommittee's findings and recommendations.

Herrera said that the United States has historically attracted top talent from around the world. He said that the risks from QIS must be appropriately balanced with the benefits, so as to not create unintended effects in other fields. Svore suggested the subcommittee recommend that companies and researchers examine their systems for vulnerabilities related to post-quantum encryption, even before standards are formally released. Herrera responded that several large companies that store customer data have already begun experimenting with post-quantum encryption. Preskill responded that the subcommittee heard from government officials that industry action before standards are formalized can lead to issues with compatibility. Svore said that the subcommittee should consider a recommendation that would promote agility in this area before formal standards are released.

Chong asked whether the subcommittee found that the United States is still able to attract large numbers of international students to work in QIS. Oliver said students may decide to go to Europe or other counties if they are concerned they will not be able to work in their preferred field. Moler said the subcommittee's recommendations seemed aimed at making it easier for scholars to stay in the US, rather than attracting more international students. Preskill responded that the subcommittee wanted to give students greater clarity about their prospects when they graduate. Oliver suggested the subcommittee seek out data on how many QIS graduates left the United States because they could not find employment. He said that those workers may return to their home countries and become economic or strategic competitors. Schoelkopf said that international students may see increased vetting as a barrier and not feel welcome to stay. He said careful balance is needed in this area and he suggested framing the vetting process as assistance to international students in finding employment.

Clarke said one issue facing industry is that an international student cannot apply for a visa before earning their degree. Schoelkopf added that the H-1B waiting period can be as long as 12 months and

that the lottery deadline in March does not align with all advanced degree timelines. Svore added that the H-1B lottery process does not align with hiring needs, because the inflexible lottery process makes lateral moves between companies and between roles difficult. Moler said these issues are not unique to QIS, but the field is an urgent priority where new efforts could be piloted. Chong said that national laboratories are critically short of postdocs, even while they have many other resources. He said that there are skilled researchers who want to work at national laboratories but are deterred by the long hiring process, which can take up to 2 years.

Svore asked if the subcommittee discussed securing domestic supply chains or reshoring production of important technologies. Schoelkopf said the subcommittee could add a statement supporting robust onshore supply chains. Herrera said that if the United States ceases engaging with global partners, they might decide to supply adversaries. Ye asked how American companies will sell products abroad. Ritter replied that export regulations need to be clear, otherwise companies might move research and production to other countries. Clarke said the subcommittee should consider other methods of consumption for QIS services, including cloud-based access. Svore asked if there are methods to detect adversarial use of QIS technology in cloud systems and if the United States could fund cybersecurity research on such a question; cybersecurity issues at all levels of the stack would be important in securing future cloud-based QIS deployments. Tahan noted an NSF workshop on detecting adversarial quantum algorithm uses held in the fall of 2022; the subcommittee had not discussed the issue. Schoelkopf and Moler agreed such issues are important and should be closely monitored.

CLOSING AND ADJOURNMENT

Moler gave a succinct readout of the session, including the subcommittee's draft recommendations. Svore suggested adding a recommendation related to supply chains. Wang suggested adding one about workforce development. Clarke suggested sorting recommendations by short-, medium-, and long-term goals. Herrera suggested focusing on creating agile intellectual property policies and fixing immigration issues. Schoelkopf suggested increasing focus on translational science, while Preskill said that fundamental science is also essential. Mason said future NQI funding should be made at the individual level as well as at the center level. Ye suggested adding a recommendation about facilitating a virtuous cycle of collaboration between labs and industry. Tahan suggested the subcommittee focus on two top issues. Mason said that the most pressing issues may not be those most actionable by the agencies. For example, issues related to infrastructure require appropriations, which the NQIAC could encourage.

Moler and Tahan thanked the members for their ongoing work, and Wong adjourned the meeting at 1:00 PM Eastern Time.

CERTIFICATION

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

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

Charlies G. Tahan, PhD
Co-Chair
National Quantum Initiative Advisory Committee