

**Summary of the Meeting of the President’s Council of Advisors on Science and Technology (PCAST)
June 30, 2020 Meeting**

Council Members: Present: Kelvin K. Droegemeier, Chair; Catherine Bessant; Shannon D. Blunt; Dorota A. Grejner-Brzezinska; Dario Gil; Sharon Hrynkow; H. Fisk Johnson; Abraham Loeb; Theresa Mayer; Daniela Rus; A.N. Sreeram; Hussein Tawbi; Shane Wall; K. Birgitta Whaley

SPEC Members: Isabel Agundis, Michelle Burbage, Bryan Changala, Dallas Elleman, Savannah Esteve, Katrina Ferrara, Kiyoo Fujimoto, Cassandra Grimes, Pippin Payne, Emily Rinko

Date and Time: June 30, 2020, 11:00 AM – 3:24 PM

Location: Virtual Meeting (Zoom)

PCAST Staff: Edward G. McGinnis, PCAST Executive Director, Designated Federal Officer

Invited Speakers: Michael Kratsios, Chief Technology Officer of the United States

Public Meeting - The session began at 11:00 AM.

Welcome and Opening Remarks
PCAST Chair Kelvin Droegemeier

PCAST Chair, Dr. Kelvin Droegemeier, welcomed PCAST members and guests to the third PCAST Meeting. Droegemeier was joined at the meeting by Mr. Michael Kratsios, Chief Technology Officer of the United States, and Mr. Ed McGinnis, PCAST Executive Director and Designated Federal Officer. McGinnis officially opened the meeting, describing the format of the remote meeting, including that it was being transcribed and recorded, and a public summary of the meeting would be posted on the Department of Energy (DOE) website. Droegemeier extended his thanks to McGinnis, and to the DOE staff who help administer PCAST on behalf of the Executive Office of the President. He welcomed new PCAST members Dr. Theresa Mayer and Dr. Hussein Tawbi to their first meeting since being sworn in as members. He also acknowledged staff of WWC who assist with meeting planning and logistics.

Droegemeier stated that the focus of the meeting was to hear presentations from the three subcommittees of PCAST, who have been working towards the goal of releasing a report on strengthening American Leadership in Industries of the Future (IOTF), a key Administration priority. He welcomed the newest PCAST members, Dr. Daniela Rus and Dr. Abraham (Avi) Loeb, and stated that three additional members were expected soon. He then proceeded to swear in Rus and Loeb.

At 11:06 AM, Daniela Rus and Abraham Loeb were sworn in as PCAST members.

Droegemeier thanked Rus and Loeb for their willingness to serve the President and the country, and expressed excitement to work with them. He noted that the National Science Board (NSB) Liaisons to PCAST were also present at the virtual meeting, and that PCAST member Dr. Dario Gil would soon be

departing PCAST to become a member of the NSB. Droegemeier thanked Gil for his service to PCAST, noting that PCAST would continue to work with him in its ongoing interactions with NSB.

Droegemeier shared an update on recent White House Office of Science and Technology Policy (OSTP) activities on research security, launched 13 months prior under the National Science and Technology Council's Joint Committee on the Research Enterprise (JCORE) Subcommittee on Research Security. The week prior, he'd made a presentation to the Federal Demonstration Partnership on research security challenges the Nation faces, including tactics being used by other countries to undermine the U.S. research enterprise, and actions taken by the Federal Government in coordination with parts of the research enterprise to balance protection of U.S. research assets with maintaining the openness critical to advance U.S. research interests. He said the slides from the presentation are available online, and they will be provided to researchers as an educational tool. He noted that policy recommendations and guidance documents for universities were expected soon.

Droegemeier invited Kratsios to share remarks.

Remarks from Michael Kratsios, Chief Technology Officer of the United States

Chief Technology Officer of the United States, Mr. Michael Kratsios, expressed enthusiasm to hear PCAST's recommendations on advancing American leadership in the industries of the future, preparing the Nation's STEM workforce, and supercharging U.S. Federal and National Laboratories. He noted that the IOTF have been a top administration priority since 2017, highlighting the launch of the American AI Initiative, the National Quantum Initiative, the National Strategy to Secure 5G, and the National Strategy for American Leadership in Advanced Manufacturing. In addition, DOE, National Science Foundation (NSF), and National Institute of Standards and Technology (NIST) are in various stages of establishing new artificial intelligence (AI) and quantum research centers and consortia. The Administration has worked to develop and guide pro-innovation regulatory agendas for AI technology, commercial drones, supersonic aircraft, and autonomous vehicles; the President has announced a commitment to double AI and quantum research and development (R&D) spending over the next two years. Kratsios expressed confidence that PCAST's recommendations would build upon and complement these robust, ongoing activities.

He provided an update on several OSTP-led private-public sector initiatives to harness emerging technologies in the fight against COVID-19. In March of 2020, the President launched the COVID-19 High Performance Computing Consortium, spearheaded by the Administration, DOE, NSF, and IBM (now grown to over 40 consortium members and 67 active research projects), bringing the world's most powerful supercomputers to tackle COVID-19 research. In addition, a multisector partnership led to the release of COVID-19, the world's largest machine-readable dataset on COVID-19 publications. This was followed-up with a call to action to develop new AI tools and techniques to mine the dataset, which has since grown to more than 167,000 scholarly articles, with nearly 2 million views and 80,000 downloads, and yielded more than 1,500 AI tools and techniques. He noted that the COVID-19 pandemic has illustrated the imperative of advancing the IOTF for both the Nation's long-term economic prosperity and national security, and the commitment of the Administration to supporting and working alongside the multi-sector U.S. R&D enterprise.

Agenda Item: Chris Liddell, Assistant to the President and Deputy Chief of Staff for Policy Coordination

Unable to join the meeting.

Droegemeier thanked Kratsios for his work and the update. He took a moment to acknowledge those who provided support to PCAST subcommittees throughout their work, including research staff from the IDA Science and Technology Policy Institute (STPI), the NSB Liaisons to the PCAST subcommittees, immediate past NSB Chair Dr. Diane Souvaine and current NSB Chair Dr. Ellen Ochoa and NSB for their support of NSB-PCAST collaborations, and PCAST Executive Director Mr. Ed McGinnis.

Droegemeier invited PCAST subcommittee chairs to present the outcomes of their work.¹

Report out from Subcommittee on an American Action Plan for Global Leadership in Industries of the Future (IOTF)

Subcommittee Chair: Darío Gil

Subcommittee Chair, Dr. Dario Gil, began by acknowledging the Subcommittee members, OSTP Subject Matter Expert (SME) Dr. Lynne Parker, STPI staff, and NSB Liaisons Dr. Suresh Garimella and Dr. Daniel Reed. He thanked the many leaders from NSF, DOE, National Institutes of Health (NIH), Defense Advanced Research Projects Agency, and other agencies who contributed their time and expertise to inform the Subcommittee in its recommendations.

The Subcommittee's charge was to collaborate on an action plan for ensuring American leadership in the IOTF (i.e., quantum information science [QIS], AI, advanced wireless communications, advanced manufacturing, and biotechnology), and identify recommendations for bridging critical gaps and to augment and strengthen existing Federal actions, such as those described by Kratsios. He noted the critical importance of IOTF for driving economic growth and employment, and meeting future global health challenges. The group's recommendations focused on AI and quantum computing, highlighting opportunities at their convergence with classical computing for solving problems previously thought unsolvable. Gil noted that these technologies could accelerate the design of new drugs, vaccines, and materials, with the potential to strengthen pandemic response, manufacturing competitiveness, and the agricultural sector. Gil noted that maintaining leadership in these areas is not assured, but rather it requires quick and decisive action, in particular to ensure an AI- and QIS-capable workforce.

He said that, while the field of AI has been around since the 1950s, in the last decade AI has become one of the most important technologies of the era, powered by exponential growth in computing power and the increasing availability of data. AI has had an important role in responding to the COVID-19 pandemic, for example in support of knowledge capture about the virus and for designing and screening molecules as drug candidates for SARS-CoV-2 treatment. He suggested that the United States is at a critical juncture for maintaining leadership in AI, identifying a need to increase investment and restructure multisector partnerships and address skill shortages in the workforce.

He went on to describe the Subcommittee's proposed recommendations for AI.

¹ These proposed recommendations were adopted by PCAST at the close of the meeting and subsequently published online. This meeting summary provides highlights of the presentations and discussion; full details of these recommendations, along with presentation slides, may be found on the PCAST website:

<https://science.osti.gov/About/PCAST/Meetings>.

The recommendations to the Federal government included growing Federal investment in non-defense AI R&D by a factor of 10 over ten years (to \$1 billion per year) and accelerating translational research in AI through agency partnerships with industry, AI Fellow-in-residence programs, and other novel cross-sector partnership models. The subcommittee also recommended creation of national AI testbeds (securing industry pledges for infrastructure support), expanding NSF's AI Centers and infrastructure programs, creating applied AI R&D centers in key domains, directing agencies to advance capabilities for AI-powered science, and tasking federal agencies such as NIST and NIH to curate and manage large AI-ready datasets to enable such research.

The Subcommittee also highlighted a need to foster increased international collaboration in AI with key U.S. allies, for example through joint international research programs or institutes, and the importance to the United States of attracting and retaining the best global talent in AI. Gil also identified an opportunity to establish an AI maturity model, an effort that could be led by NIST working with other agencies and active industry engagement. This effort would include establishment of a framework for technology assessment and precision regulations, and standards for trustworthy AI—including fairness, explainability, security, reproducibility, and transparency.

Finally, Gil said the IOTF Subcommittee proposed recommendations for driving AI education and training opportunities, for example by securing industry pledges to scale up investments in support of AI certifications, re-skilling programs, research, and fellowship and residency programs. He said the Subcommittee also identified a need to develop AI curricula and performance metrics from K-12 through the post-graduate level, to advance AI training programs in partnership with educational institutions, to create recruitment and retention incentives for AI faculty at universities, and to increase NSF and Department of Education investment in AI educators, scientists, and technologists. Gil noted that the Subcommittee sees AI as one of the top technologies for advancing the health, prosperity, and security of the Nation, and believes it is time to scale AI.

Gil then turned to QIS—including the fields of quantum sensing and metrology, quantum networking and communication, and quantum computing. He commented that the passage of the National Quantum Initiative Act was a seminal moment for QIS in the United States, heralding a range of Federal activities.

The Subcommittee's first proposed recommendation for QIS is to engage industry in building world-class quantum infrastructure at scale. They also suggested investment of \$100 million annually over 5 years to create federally funded National Quantum Computing User Facilities to complement anticipated industry investments of ~\$2 billion in quantum computer systems R&D. He compared this approach to the early development of the Nation's high performance computing facilities at National Laboratories. Similarly, analogous to the creation of ARPANET, a precursor to today's internet, the Subcommittee recommended that the United States work to lead the world in creation of a quantum intranet and internet, which could catalyze demonstration of new quantum technologies. The Subcommittee also recommended creating a pre-competitive quantum research collaboration and providing curated access to quantum technologies.

Gil also emphasized the importance of foundational science, noting that many of the intellectual drivers of QIS come from academia, where exploration of the boundaries of conventional disciplines and pushing the frontiers of knowledge are essential elements. The Subcommittee recommended that such discovery-based QIS R&D be fostered across all sectors, leveraging the strengths of each, along with the creation of Foundational QIS Discovery Institutes. Recommendations for building a quantum-enabled

workforce included creation of novel educational programs with skills-based credentials as well as leveraging Federal programs to establish new QIS internships and drive diversity and inclusion in the quantum workforce. As with AI, Gil emphasized the importance of attracting and retaining the best global talent in QIS and building international R&D collaborations at the frontiers of QIS. Finally, the Subcommittee recommended continuous evaluation of the field's security implications.

Gil then identified the potential for accelerating discovery at the intersection of high performance computing, AI, and quantum computation—each currently at a different level of maturity—by leveraging their complementary capabilities in an Accelerated Discovery Workflow. To work towards this vision, the Subcommittee recommended expanding and redefining the mission of the National Strategic Computing Initiative, piloting an *Accelerated Discovery Workflow* in newly proposed IOTF Institutes (discussed in the Federal and National Laboratories Subcommittee presentation), and re-energizing and scaling up the Materials Genome Initiative through this approach as AI and QIS continue to mature.

Gil opened up the conversation for PCAST member discussion. Dr. Birgitta Whaley highlighted the importance of cross-sector partnerships (industry, government, academia, and private foundations) to make progress in QIS. She said that the field is at a critical juncture: while new quantum algorithms offer the potential to change the way information is processed, the challenge of building the machines that can implement these algorithms is enormous, as the technology is fundamentally different from that underlying today's computers. While the pace of progress is increasing, she said, it is clear that no one sector can do this alone. Instead, it will require synergy between industry (working to develop quantum computers at scale), the National Labs (driving development of potential applications), and university researchers (working on fundamental science and engineering required to build stable systems and develop new algorithms). In addition to quantum scientists, quantum engineers will be needed. Long-term, foundational research is needed to address open questions about the boundaries of what the technology can achieve, and how it can be used to advance science and benefit society.

Droegemeier reiterated the importance of cross-sector partnerships and a whole-of-nation approach to achieving these goals. He suggested that today's notions of quantum engineers and the quantum workforce may transform over the next five years. Dr. Dorota Grejner-Brzezinska commented that she found it uplifting to hear about the Administration's actions and the Subcommittee's recommendations in AI and QIS, particularly the value of a multisector approach for accelerating progress from discovery to application. She also suggested a need to focus on K-12 education to prepare individuals early for work in these fields—with curricula driven by academics but infused by industry experience and knowledge of skills requirements.

Tawbi also voiced his appreciation for these efforts. From his experience as a physician-scientist and cancer researcher, he said he has always felt the urgency of scientific discovery for saving lives. He commented that the COVID-19 pandemic illustrates how critical it is to accelerate discovery from the bench to the bedside—not only as a matter of improving human health, but also as an issue of economic and national security. He thanked his colleagues for these recommendations, noting that they are timely.

Droegemeier thanked Tawbi for his comments, and reiterated that these frontier fields could have potentially transformative impacts on society. Kratsios commented that the Administration is proud of the work it has done in these areas and is glad to have PCAST to provide input for turbocharging these activities. He expressed his enthusiasm for these recommendations and for starting to work with Congress and the Federal agencies to implement them. He thanked the Subcommittee for their work.

Report out from Subcommittee on Meeting National Needs for STEM Education and a Diverse, Multi-sector Workforce (STEM)

Subcommittee Chair: Cathy Bessant

Subcommittee Chair, Ms. Cathy Bessant, thanked Droegemeier, fellow PCAST members and guests, fellow Subcommittee members, NSB liaisons, OSTP SMEs, and STPI staff. She noted that PCAST's engagement with NSB and NSF greatly enriched the group's work.

She described the work across all three subcommittees as parts of an integrated whole. The recommendations leverage and rely on each other, and their concerted implementation will ensure success. Themes of talent and workforce needs are woven throughout all of the Subcommittees' work and recommendations.

Bessant shared some insights that helped drive this work. She said that 2020 is the year in which science, technology, and workforce have never been more important. She pointed to the importance of technical connectivity for supplementing or replacing physical connectivity, exponential growth in adoption of digital technology, and a new need for manufacturing at speed and scale with targeted delivery—along with an increasing need for protecting data that is now being connected and shared in new ways.

Science and technology's role as a significant part of every supply chain and all aspects of economic vibrance has never been clearer, including for the workforce. Industry has had to learn rapidly how to virtually hire, manage, skill, and re-skill workers; the times have also illustrated the importance of a flexible and adaptive workforce. Remote delivery in education and training also makes technology a critical element of the education supply chain. Internet bandwidth has become an almost fundamental need in households. Beyond this connectivity, success in home schooling requires technological knowledge in the home; its availability will affect the ability of the next generation to achieve its full potential.

As a business person, Bessant said she has seen that the importance of science and technology for the supply chain and economic vibrance has been clear to those in Washington, on Wall Street, and in universities and technology companies—but not necessarily to those on Main Street. The events of 2020 have changed this; everyone now realizes the importance of science and technology in their lives. Bessant suggested that the opportunity, timing, and national will for advancing science and technology have never been stronger, noting that PCAST's work comes at a unique moment where there is a pull and demand for the ideas that the group may have had to push even a year ago.

Bessant noted that the need for STEM workers is real, and can only be expected to grow—especially in areas like computer science. To meet this need, the United States must leverage the full potential of its human resources for STEM by overcoming historical barriers to inclusion of individuals because of race, gender, income, educational availability, or beyond. The Subcommittee believes that there is a need to expand the variety of career pathways into STEM fields—for both school-aged students and those already in the workforce—as the IOTF continue to expand. The Subcommittee also recognized activity in educational systems related to global perspectives, technological readiness, and distance versus place-based learning. The Subcommittee felt a mandate to help ensure that the system that emerges from this disruption is hardy, prepared for the future, and well-invested.

The Subcommittee aimed to complement and supplement the priorities and recommendations of the National Strategy for STEM Education, and to complement and reinforce the recommendations from their fellow PCAST subcommittees. The STEM recommendations are based around two priority areas: 1) building the workforce of the future by creating STEM education and training opportunities for individuals from all backgrounds, and 2) creating new curricula and universal and skills-based licenses and certifications for IOTF. Bessant invited fellow STEM Subcommittee member, Dr. Sharon Hrynkow, to present the first set of recommendations.

Hrynkow reiterated that the group was thrilled with the workforce-related recommendations from the other two subcommittees; the STEM Subcommittee aimed to amplify and complement, rather than duplicate them. She noted that talent is universal; the challenge is to find, nurture, and deploy it in support of IOTF. PCAST is committed to ensuring that historically underrepresented and underserved individuals have the opportunity to participate fully in the science and technology enterprise and the workforce of the future. She pointed out that STEM jobs tend to be higher-paying, come with mobility because they are based on competency, and engender a sense of community. In addition to building the scientific and economic capabilities for the future, STEM can also empower individuals from any background.

The committee's first recommendation is for cross-sector development of programs to bring non-STEM workers into the STEM workforce. This could involve learning from instances where individuals have successfully transitioned to STEM later in their careers to develop best practices for enabling such transitions. For this push to succeed, there must also be a pull; the Subcommittee suggested that public and private sector employers commit to hiring individuals from backgrounds beyond the traditional or classical STEM disciplines. The second recommendation is for organizations to come together to create STEM retraining boards that connect individuals to new training opportunities for re-skilling or up-skilling and certification, and to jobs requiring these skills. This recommendation is particularly important in the context of workers displaced as a result of the COVID-19 pandemic. The Subcommittee envisions creation of fifty boards, each funded at \$1 million through public-private partnerships, to be activated by 2022. These boards could work with local employers in partnership with educational institutions, including community colleges, Historically Black Colleges and Universities (HBCUs), and high schools for job-relevant reskilling, or to create internships or apprenticeships. Sharon noted that the PCAST Students, Post-Doctoral Scholars and Early Career Professionals (SPEC) Subcommittee has already provided keen insights about local and individual challenges—for example, a need for more mentors at community colleges. She reiterated that these boards would serve as matchmakers between students and opportunities, using best practices to help individuals and drive local economies. Hrynkow concluded by saying there is an urgent need to start building these programs now.

Bessant described the Subcommittee's second priority: creating curricula for IOTF. Recommendation three called for a commitment of Federal funds—matched by support from the private sector and universities through endowments, foundations, or in-kind support—to create industry-recognized curricula and work-based learning and training programs for IOTF. Universally recognized curricula would enable portability of skills and geographic mobility. Consistency of the approaches, language, and prioritizations in curricula could help to expand the pool of individuals who would consider and ultimately pursue STEM careers, including those from underrepresented groups.

The Subcommittee's fourth recommendation was the creation of universal skill-based licenses and certifications for IOTF through public-private partnerships—informed by recommendations from experts in industry and professional societies. While licensing and certification might be uncommon for many STEM disciplines, she noted that it is common in some sectors, pointing to medical certifications (e.g., LNP, RN, MD, DDS) for which skills and roles are clearly defined. Examples from financial services include CPAs and CFPs, with a series of testing and licensing requirements. The Subcommittee recommends a high sense of urgency in establishing such certifications for STEM professions, with an aspirational goal of industry partners aiming for 50 percent of hires into suitable tech-based positions from the pool of newly licensed or certified individuals by 2024.

Bessant invited other STEM Subcommittee members to share additional comments. Dr. Fisk Johnson noted that the events of recent unrest in the country underscored the importance of creating greater economic opportunity for underrepresented minorities in America. He shared his belief that STEM is a critical area for doing this, and that the group's recommendations and the National STEM Education Strategy are important ways of doing this and are good for national and economic security.

Discussion

Droegemeier applauded the group for their focus on bringing in people from non-traditional backgrounds—who are not always welcomed into STEM—and for their emphasis on skills. He said the latter is consistent with the President's Executive Order emphasizing aggregations of skills rather than degrees, with opportunities for individuals to mix and match those required in the job market. Mayer commented that there is nothing more important to the Nation than building the workforce of the future, and engagement of underrepresented groups is critical for overcoming the growing gaps and needs within many areas of IOTF. She noted the challenge in academia—especially in areas such as computer science—with recruitment and retention of the best and the brightest faculty. She said that it is increasingly important to find new, flexible, and agile models that move beyond conventional approaches to instruction, and to look across all sectors for help in training the future workforce.

Loeb saluted the Subcommittee's work and highlighted another important dimension: ensuring that scientists and engineers are trained to think about ethical implications of new technologies, and to develop guiding principles for their application in society. This has been seen in recent discussions about COVID-19 and AI-based tracking of individuals through cell phone apps. Other examples related to medical applications of AI include whether life and death decisions should be managed by computers and protection of personal health information. Droegemeier agreed, noting that Kratsios has worked hard on principles for the ethical use of AI with the Organisation for Economic Co-operation and Development, the United States joined the Global Partnership on AI, and the Administration continues to work in this area. Dr. Carl Lineberger reiterated the importance of both broadening the base of the STEM workforce and raising the level of achievement in order for the Nation to succeed.

At 1:01 PM, the meeting recessed for lunch, and reconvened at 2:00 PM.

Report out from Subcommittee on New Models of Engagement for Federal and National Laboratories in the Multi-Sector R&D Enterprise (Labs)

Subcommittee Chair: A.N. Sreeram

Subcommittee Chair, Dr. A.N. Sreeram, began by thanking Dr. Paul Dabbar, DOE Under Secretary for Science; Dr. Chris Fall, Director of DOE's Office of Science; Dr. Thomas Zachariah, Director of Oak Ridge National Laboratory; Dr. Mike Witherell, Director, Lawrence Berkeley National Lab; and Dr. Chi-Chang Kao, Director of the SLAC Linear Accelerator Laboratory, for generously sharing their time and expertise with the Subcommittee, and enabling Subcommittee members to talk with staff during site visits. He also thanked PCAST and the Subcommittee members, NSB liaisons Dr. Artie Bienenstock and Dr. Julia Phillips, Dr. Pat Looney from OSTP, and STPI researchers for their contributions and support of the Subcommittee's work.

The Subcommittee's objective was understanding whether new models of collaboration are necessary for accelerating American innovation and leadership in IOTF. Sreeram summarized the group's primary recommendation as establishment of a new type of world-class, multi-sector R&D institute, called IOTF Institutes, to catalyze innovation from discovery research to commercialization by: 1) bringing together all sectors of the U.S. science and technology enterprise, 2) setting intellectual property (IP) terms for commercialization and innovation at scale, and 3) leveraging regionally impactful hubs for technology, economy, and skilled labor.

The Subcommittee found that the United States has tremendous strength and capabilities and a solid R&D foundation in its National and Federal Laboratories; public-private partnerships are fundamental to American success; and invention is omnipresent in these labs. They also found that commercialization and innovation were somewhat inhibited, suggesting a need to reduce administrative loads and remove some historical barriers. Sreeram also highlighted the importance of attracting the world's best scientists and engineers, sustaining fundamental research, and translating it to yield economic benefits. He suggested that industry participation is necessary for a strong return on investment for Federal R&D. He also pointed to how emergency use authorizations enabled the private sector to respond to demand for ventilators and personal protective equipment in the face of COVID-19.

Sreeram commented on industry priorities of shareholder return, earnings on investment, and R&D infrastructure as immense assets built over time. He also noted that university research is more publication-driven, and industry research is more patent-driven—though both produce both. He also addressed the geographic diversity of innovation hubs throughout the Nation, noting that they are currently focused on the coasts, with Silicon Valley a prime example; economic opportunity zones are one mechanism for encouraging diversification of hub locales. He also noted the importance of domestic manufacturing as the largest job multiplier of any industry and necessary for securing domestic supply chains.

The IOTF Institutes would each involve collaboration of hundreds to thousands of researchers from across the science and technology enterprise, leverage two or more IOTF areas together to accelerate progress, pilot new IP terms, and chart a path towards building factories of the future. Ideas for flagship IOTF Institutes include combining 1) AI and advanced manufacturing or 2) AI and biotechnology. Today's factories are clean and high-precision, and trending towards increased customization via additive manufacturing and the use of "digital twins" (digital simulations that enable performance optimization)—combining both could lead to great competitive advantage in factories and across the supply chain. An IOTF Institute could be an accelerator for achieving "Industry 4.0"—a fourth industrial

revolution. A Biotechnology Institute could leverage AI to advance fundamental understanding of cellular function, with critical applications for medicine, biosecurity, food security, and biosphere sustainability. He named several visionary examples from precision agriculture, pointing to opportunities to improve efficacy of crop spraying or fertilization techniques to minimize environmental toxicities.

He then described key opportunities for engagement in the IOTF Institutes by sector, and highlighted the importance of proactively adapting STEM curricula for the IOTF, and providing education and training beyond classical degrees. He also emphasized that the IOTF Institutes can build on existing infrastructure and expertise at DOE's National Labs and other Federal Labs. In summary, he noted that the Subcommittee strongly recommends that policy be introduced in the near term to formalize the design and implementation of IOTF Institutes.

Discussion

Mr. Shane Wall noted that these investments and cross-sector collaboration are critical for the United States to maintain long-term competitiveness in the global R&D arena. He amplified several key points: 1) the importance of getting the right IP terms, 2) the objective of translating research to innovation at scale, and 3) the need to diversify where R&D is done in the country through incentives such as opportunity zones. Dr. Shannon Blunt highlighted the potential for IOTF Institutes to strengthen the basic to applied research feedback loop, to cross-leverage IOTF for mutual amplification, to help bridge the "valley of death" via attractive IP terms, and to maximize intellectual collisions to spur radical new ideas. Rus underscored the importance of AI and computation for creating a more efficient and customized manufacturing system and opportunities for local sourcing and full supply-chain impact. She also emphasized that the highly interdisciplinary work entailed by the new institutes will require the education programs advocated by the previous two subcommittees, and that broad education in AI, computation, and technology is an important part of literacy in the 21st century.

Droegemeier closed out discussion of the three subcommittees' recommendations, noting the three key themes of 1) stimulating a multi-sector enterprise for IOTF, 2) strengthening both traditional and non-traditional pathways to build skills for a workforce of the future, and 3) leveraging U.S. National Labs to build factories of the future—through an all-hands-on-deck approach. He said the ideas presented were consistent with the messaging of the President and his Administration.

Discussion with Students, Post-Doctoral Scholars, and Early Career Professionals (SPEC) Subcommittee **Subcommittee Chair: Sharon Hrynkow**

Droegemeier introduced the SPEC Subcommittee, present for the first time at a PCAST meeting. Comprised of 10 students or early-career individuals spanning a diverse range of backgrounds and locations, to provide intellectual energy and new perspectives and insights to PCAST.

SPEC Subcommittee Chair, Dr. Sharon Hrynkow, said she views SPEC members as future leaders in STEM who can serve as a resource to PCAST by sharing fresh perspectives and new ideas. She noted that one of the SPEC members would serve alongside her as Subcommittee Co-Chair. She invited the SPEC members to introduce themselves.

After introductions, Droegemeier moderated a brief discussion. Loeb asked SPEC members to comment on the challenges they're seeing in the COVID-19 era, and Rus asked what changes they would find most helpful in continuing their work and studies during the pandemic. Mr. Bryan Changala responded that he

planned to enter the faculty job market in a few years, and there is a feeling in the community that plans may need to be postponed due to economic uncertainty; he said some sort of new support for meeting challenges in the job market or enabling individuals to continue in their current research would be helpful. He noted that he has been lucky to have strong mentorship, but others may need improved mentoring to face career transitions. Ms. Isabel Agundis agreed, and noted that things were challenging for her as an undergraduate in STEM, as classes will be online and she will not have access to resources such as the library. Some of her peers have felt discouraged about continuing in school because of online classes. She also noted that many internships have been canceled, which will make it difficult for students to build up the experience that will help them get jobs after college.

Droegemeier noted that OSTP has worked on reopening and reinvigorating the research enterprise, recently holding meetings and calls with university leaders and professional societies to understand and harvest lessons learned to become more resilient, effective, and efficient. As was done with emergency use authorizations and clinical trials to reduce red tape for pandemic response activities, the Administration is seeking ideas for modifying regulations to address pandemic-related challenges in higher education. He noted that science and technology have enabled great adaptability, pointing to how high speed networking has enabled remote meetings and schooling—including the current teleconference—and pointed to opportunities for the science and technology enterprise to become even more robust than it was before. Droegemeier thanked all SPEC members and expressed his excitement for their participation moving forward.

Public Comment Period:

There were no requests for public comment.

Vote to Adopt the Draft Report

Droegemeier thanked the PCAST members for their work in developing recommendations, along with the OSTP SMEs, NSB liaisons, and STPI and DOE colleagues for their support of these efforts. He noted that the report would undergo minor, non-substantive, editorial corrections and formatting. Wall moved that PCAST approve the draft report as described; the motion was seconded.

At 3:20 PM PCAST officially adopted the report and its recommendations by unanimous voice vote.

Droegemeier said that upon completion of copyediting, the report will be posted to the PCAST website along with the presenters' slides.

Meeting Wrap-up and Adjournment

Droegemeier wrapped up the meeting by pointing to steps ahead. The Administration plans to work with the agencies and Congress to implement the recommendations in the report. The Administration will continue to harvest the input of PCAST members and keep them apprised on implementation efforts moving forward. Droegemeier noted that PCAST's interactions with the NSB will continue under the new NSF Director, Dr. Sethuraman Panchanathan (a current NSB member who will become an ex-officio NSB member as Director) and with newly elected NSB Chair Dr. Ellen Ochoa. McGinnis expressed his gratitude to PCAST members for their hard work, lauding their resilience, resourcefulness, and commitment to the Nation. Droegemeier adjourned the meeting at 3:24 PM.

Respectfully Submitted:
Edward G. McGinnis
Designated Federal Officer

I hereby certify that this summary of the PCAST meeting on June 30, 2020 is true and correct to the best of my knowledge.