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PCAST Issues Recommendations to Grow Research and Workforce Opportunities in Industries of the Future

Lewis-Burke Associates LLC – July 1, 2020

On June 30, 2020, the President's Council of Advisors on Science and Technology (PCAST) had their third meeting under the Trump Administration. The purpose was to provide the Office of Science and Technology Policy, led by Dr. Kelvin Droegemeier, recommendations on how to advance and strengthen federal government efforts in three key areas: Industries of the Future, the workforce of the future to support the Industries of the Future, and new models of engagement between national laboratories, research universities, and industry to deploy and commercialize new technologies. PCAST members proposed 21 recommendations and unanimously approved the report describing each recommendation, which should be publicly available within the next month. Dr. Droegemeier made clear that many of the recommendations are already under consideration for the fiscal year (FY) 2022 budget request and outyears.

The focus of the recommendations were on three Industries of the Future—Artificial Intelligence (AI), quantum information sciences (QIS), and advanced manufacturing. The other two Industries of the Future are advanced communications and biotechnology. Some of the most prominent recommendations include:

- Grow non-defense federal investments in AI by 10 times over the next 10 years—from approximately $1 billion a year in FY 2020 to $10 billion a year by 2030;
- Establish Industries of the Future Institutes that tackle research and development needs of more than one Industry of the Future and bring together world-leading researchers from different disciplines and institutions (academia, national labs, industry) to accelerate the pace of innovation from discovery research to development, deployment and commercialization of new technologies and will create technology pathways for Factories of the Future;
- Create national AI testbeds, and in particular expand the National Science Foundation's (NSF) AI Institutes with at last one AI Institute in each state and create a National AI Consortia among all the AI Institutes to share capabilities, data, and resources;
- Create Department of Energy-funded National Quantum Computing User Facilities with $100 million per year over five years;
- Launch a Quantum Internet and Intranet to develop the infrastructure for new quantum communication technologies;
- Create Foundational QIS Discovery Institutes at research universities to focus on foundational and blue-sky research and serve as academic-industry consortia to develop quantum technologies; and
- Address future workforce needs by creating STEM training and education opportunities for individuals from all backgrounds, including underrepresented, diverse populations and individuals from non-STEM background and create new curricula and universal skills-based licenses and certifications for Industries of the Future.

In addition to the discussion on the recommendations, two new members joined and were sworn into PCAST—Dr. Abraham Loeb from Harvard University and Dr. Daniella Rus from MIT. They join 12 current members with the list of members and biographical information available here. Dr. Droegemeier also

announced that three new members have been nominated, are currently being vetted, and should be joining before the next meeting in the Fall.

More information on each of the recommendations is available below.

Recommendations from the Subcommittee on American Global Leadership on Industries of the Future

The Subcommittee focused primarily on AI, QIS, and high-performance computing. The top priorities were recommendations to leverage Industries of the Future discoveries and technologies to improve the nation's ability to respond to critical challenges, such as global health crises, and develop a AI- and QIS-capable workforce.

The 21 specific recommendations include:

Artificial Intelligence

1. Grow federal non-defense investments in AI research and development by 10 times over 10 years. This is consistent with current trajectories in the FY 2021 President's budget request and expected FY 2022 budget request in AI. The recommendation would require growing AI investments $1 billion every year. As an example, PCAST highlighted that in FY 2020 NSF plans to spend $487 billion on AI research and development. PCAST recommends that NSF grow its investment to $1 billion to fund 1,000 additional awards with no loss of quality and would significantly grow the workforce.

Table 1. *Proposed Federal Budget Ramp for Non-Defense AI Research*

2020	2022	2024	2026	2028	2030
$1B	$2B	$4B	$6B	$8B	$10B
Consistent with 2021 Federal Budget Request		Recommending sustained investment growth of $1B/year in non-defense research funding through 2030			

2. Accelerate translational AI research, which includes all federal agencies elevating the importance of partnerships with industry to develop and deploy AI applications at scale, create "AI Fellow-in-Residence" positions at federal agencies, and pioneer novel academia-industry AI partnerships.
3. Create National AI Testbeds, including expanding NSF's AI Institutes to at least one in each state, secure U.S. industry investment pledges to support core AI infrastructure at research universities such as high performance cluster donations, and task the National Institute of Standards and Technology (NIST) and the National Institutes of Health (NIH) with curating, managing, disseminating AI-ready large data sets.
4. Foster increased international collaboration in AI with key U.S. allies, including formal international partnerships in AI research and development and define joint international research programs.
5. Attract and retain the best global talent in AI.

6. NIST should establish an AI maturity model, in partnership with industry, for trustworthy AI systems and inform the development of open, consensus-based, internationally recognized ethical use of AI.
7. Drive opportunities for AI education and training, and in particular secure U.S. industry pledges to scale investments on training and education of the U.S. workforce in AI, develop AI curricula and performance metrics at K-12 through postgraduate levels and for certificate/professional programs, train a highly skilled AI workforce at secondary schools and universities, create incentives, recruitment and retention programs for AI faculty at universities, and increase NSF and Department of Education investments in AI educators, scientists, and technologists at all levels.

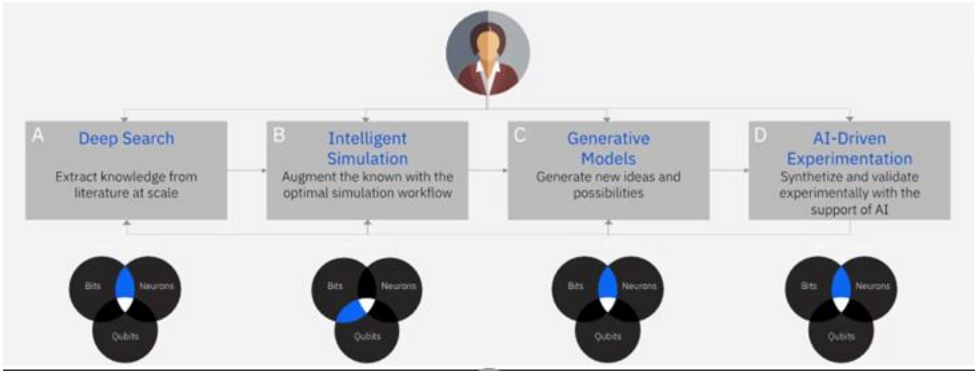
Quantum Information Science

8. Engage industry in building world-class quantum infrastructure at scale, including investing in design, construction, and deployment of high availability quantum computing systems, developing a roadmap to at least double system performance annually, and build cloud-based quantum computational centers and associated services.
9. Invest $100 million per year over five years to create DOE-funded National Quantum Computing User facilities.
10. Launch a Quantum Internet and Intranet to help develop common infrastructure for new quantum communications technologies and exploit synergies between quantum computing and communication.
11. Attract and retain the best global talent in quantum science and technology.
12. Foster discovery-based science that explore the frontiers of QIS and related technologies and build intellectual capacity in both foundational and applied research.
13. Provide curated access to quantum technologies to speed development of practical quantum computing applications.
14. Create a pre-competitive research collaboration between industry and academic teams to develop hardware by leveraging NIST's QED-C.
15. Create Foundational QIS Discovery Institutes with academic-industry consortia focused on foundational and blue-sky research.
16. Build a quantum-enabled workforce, including pre-and post-collage and non-skilled workforce quantum educational and training programs, leverage academic-industry partnerships to create new curricula and teach across traditional disciplinary boundaries of science and engineering, identify co-teaching opportunities by national lab, industry, and academic scientists, create industry-relevant training and skills-based certification programs, and leverage federal programs to drive diversity and inclusion in the quantum workforce.
17. Build international research and development collaborations at the frontiers of QIS, such as small scale discovery-based partnerships between U.S. universities and selected foreign university partners to explore fundamental research in key areas.
18. Continuously evaluate national security implications of QIS.

Accelerated Discovery

19. Expand and redefine the mission of the National Strategic Computing Initiative to include AI and QIS and move beyond computing power.

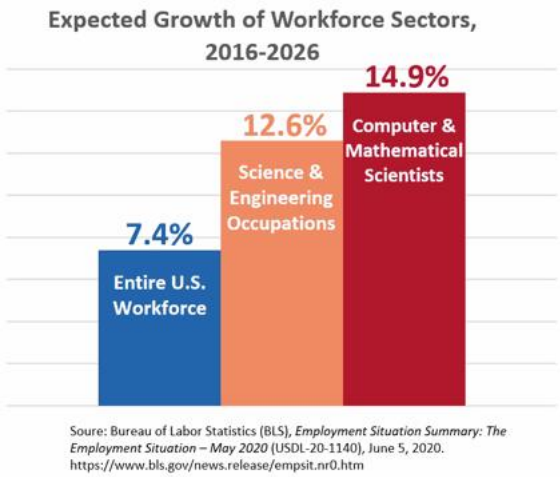
20. Establish Industry of the Future Institutes and pilot the Accelerated Discovery workflow that is focused on the convergence of capabilities and technologies (see graphic below)



21. Re-energize and scale up the Materials Genome Initiative to take advantage of AI and QIS to design new materials for a broad set of applications.

<u>Recommendations of the Subcommittee on Meeting National Needs for STEM Education and a Diverse, Multi-Sector Workforce</u>

The focus of this subcommittee was to help prepare the American workforce by improving access to high quality education and training programs in STEM, especially in areas relevant to Industries of the Future. The recommendations were driven by a recognition that the need for STEM workers in the U.S. is growing. Growth in science and engineering occupations is forecast to substantially outpace the U.S. workforce as a whole, especially in computer and mathematical sciences that are critical to AI and QIS.



Based on these statistics, PCAST members emphasized the need for the U.S. to leverage the full potential of its human resources by overcoming historical barriers that have limited inclusion of many underrepresented and underserved communications in STEM. The four recommendations include:

Building the Workforce of the Future

1. Industry, academic institutions, and professional societies should develop programs to provide non-STEM workers with professional competencies that give them a role in the STEM workforce of the future, including pledges from public- and private-sector employers to hire newly skilled STEM workers from non-traditional background into STEM positions.
2. NSF should establish a grant program to create a pilot multi-sector, workforce of the future, STEM retraining boards. PCAST recommended 50 competitive grants of up to $1 million each for the initial formation of local/regional U.S. STEM retraining boards. The Boards would be public-private partnerships between local governments, regional universities, community colleges, industry certification institutions, local employers, and trade groups.

Creating Curricula for Industries of the Future

3. Create industry-recognized curricula and work-based learning and training programs focused on AI, QIS, and advanced manufacturing using federal funds, matched by private-sector and university support.
4. Create universal skill-based licenses and certifications targeting industries of the Future through public-private partnerships.

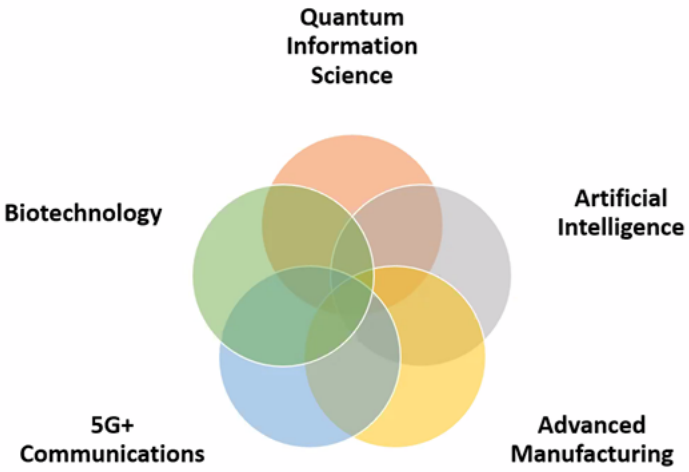
<u>Subcommittee on New Models of Engagement for Federal and National Laboratories in the Multi-Sector R&D Enterprise</u>

The focus of this subcommittee was to assess whether new collaboration models are necessary to accelerate American innovation and leadership in Industries of the Future. The main recommendation was to establish Industries of the Future Institutes and eventually Factories of the Future. Industries of the Future Institutes would support innovation at all stages of research and development—from discovery research to development, deployment and commercialization of new technologies. The focus of the Institutes would be to create partnerships across industry, national labs, and academia, establish clear intellectual property terms for commercialization at scale, and leverage regional hubs for technology, economy, and skilled labor including Opportunity Zones. A distinguished feature would be a focus on more than one Industry of the Future and the opportunities related to convergence of different technologies and experts from different disciplines (see graphic below). PCAST highlighted two examples of possible Institutes—one on AI and Advanced Manufacturing to drive innovation to support future U.S. competitiveness in manufacturing and a Biotechnology Institute to integrate AI and advanced manufacturing to advance biotechnology and in particular advances in biosecurity, food security, new therapies, and biosphere sustainability.

Rationale for Combining IotF Elements in IotF Institutes

Independently:
Advances in each of these industries are important in their own right, with great opportunities for discovery.

Combined:
The convergence of these fields promises to accelerate progress, with the potential for profound societal benefits.



PCAST highlighted specific benefits for research universities to participate in this Institutes, including proactively adapting curricula in STEM disciplines for Industries of the Future, promote cross-discipline efforts in data science, and foster collaboration between industry and national laboratories to drive integrated efforts across Industries of the Future. The Institutes would also be charged with charting a technology pathway for Factories of the Future. The goal would be use additive manufacturing and digital twins to increase global competitiveness of U.S. manufacturing. The future vision is to gain a competitive advantage not just in efficiencies at individual manufacturing plants, but also entire supply chains—from the supply of raw materials and goods, to individual plants, to the downstream distribution of finished goods. PCAST believes that the combination of reliable digital twins, smart manufacturing, AI, and quantum computing will give American industry an unprecedented competitive advantage.