VISITING COMMITTEE ON ADVANCED TECHNOLOGY (VCAT or Committee)
MINUTES OF THE JUNE 4TH and 5th, 2019 MEETING
GAITHERSBURG, MD

ATTENDANCE:

Visiting Committee Members Attending
Adler, Allen
Alexander, Jay
Brooks, Rodney
Cerf, Vinton
Colwell, Rita
Fischer, George
Garvey, Michael (Mike)
Ishak, Waguih
Jackson, Keoki
Kaler, Eric
Khan, Mehmood
Ku, Katharine
Prafullchandra, Hemma
Sizer, Theodore (Tod)
Vasko, David (Dave)
Wasserman, Gail

Designated Federal Officer
Shaw, Stephanie

NIST Leadership Board
Boehm, Jason
Brockett, Del
Copan, Walter
Dimeo, Rob
Dowell, Marla
Fangmeyer, Bob
Gayle, Frank
Harary, Howard
Jenkins, George
Kimball, Kevin
Lin, Eric
Mackey, Elizabeth
Olthoff, James
Porch, Susanne
Romine, Charles
Schiller, Susannah
Singerman, Phillip
Thomas, Carroll
Vaughn, Robert (Skip)
Williams, Carl
Wixon, Henry

NIST Staff
Allocca, Clare
Andrade, Dorianna
Avila, Regina
Baltic, George
Borchers, Julie
Bunch, Robin
Coraggio, Mary-Deirdre
Davis, Ben
Davis, Rick
Dohne, Kirk
Espinal, Laura
Evans, Heather
Fasolka, Michael
Fowler, James
Fronczek, Lisa Jean
Gendron, Cheryl
Gibson, Samantha
Goldstein, Barbara
Gonzalez, Carlos
Hain, Toby
Hardis, Jonathan
Hendricks, Jay
Hickernell, Robert*
Hight-Walker, Angela
Holbrook, David
Huergo, Jennifer
Ivy, Nahla
Jillavenkatesa, Ajit
Jones, Ron
Kramar, John
Kushmerick, James
Lawson, Jeremy
Lee, Sue
Liang, Hong
Lin-Gibson, Sheng
Madsen, Mark
McBride, Timothy
McCasey, Olivia
McTigue, Kathleen
Na, Charles
Nair, Rajesh
Neumann, Dan
Newton, Thomas
Pevenstein, Jack E.
Pierce, Donald
Rhyne, James
Rudnitsky, Robert
Saundry, Claire
Sberegaeva, Anna
Schlenoff, Craig
Scholl, Matthew
Schufreider, James
Seiler, David
Semerjian, Hratch
Shen, Vincent
Shyam-Sunder, Sivaraj
Silverthorn, Courtney
St. Pierre, Jim
Stubblefield, Nicholas
Szakal, Christopher
Tabassi, Elham
Tarlov, Michael
Thorne, Roger
VanLandingham, Mark
Walker, Troy
Warren, James
Welsh, Kelly
Zangmeister, Rebecca
Zielinski, Paul
Zimmerman, Neil
Zimmerman, Steven

Others
Ambrose, Mitch – American Institute of Physics*
Bender, Avi – National Technical Information Service
Hore, Michael – Case Western Reserve University
King, Hubert – ExxonMobil Corporate Strategic Research
Kung, Harriet - Department of Energy
Lee, Peter – Department of Energy

Lee, Young – Stanford University
Leland, Cogliani – Lewis-Burke Associates LLC
Louca, Despina – University of Virginia
Milliken, Lindsay – Lewis-Burke Associates LLC
Parker, Lynne – Office of Science & Technology Policy
Phillips, Julia – American Physical Society
Slakos, Frances – American Physical Society
Staskiewicz, Samantha – American Institute of Physics
Tessema, Guebre – National Science Foundation
Wagner, Norman – University of Delaware

*Participated Remotely

Tuesday, June 4, 2019

Call to Order - *Dr. Rita Colwell, VCAT Chair*

Dr. Colwell called the meeting to order at 8:30 a.m. and reviewed meeting logistics. Dr. Colwell introduced the three new members to the Committee – Dr. Vinton Cerf, Dr. Mehmood Khan, and Dr. Eric Kaler – and welcomed them. Dr. Colwell turned the meeting over to Dr. Copan.

SESSION I: NIST UPDATE

NIST Update and Agenda Review – *Dr. Walter Copan, Under Secretary of Commerce for Standards and Technology and NIST Director*

Dr. Copan began his presentation with the summary of the program agenda items for the day. He also announced that unfortunately Dr. Kelvin Droegemeier, the Policy Director of the Office of Science and Technology, was called away at the last moment and would not be able to provide the overview for Session II, Administration's Priorities for Science and Technology, however, Dr. Jason Boehm would provide an overview on national and NIST strategic priorities. Dr. Copan then welcomed and provided a brief background summary of the new VCAT members, Dr. Vinton Cerf, Dr. Mehmood Khan, and Dr. Eric Kaler.

Dr. Copan provided an update to the VCAT on NIST activities and program that had taken place since the previous meeting. Dr. Copan's talk covered the current NIST budget situation, recent programmatic highlights, steps NIST is taking to address challenges related to security, how NIST is addressing equity in career advancement, as well as highlights of recent international engagement. The full talk can be found at https://www.nist.gov/sites/default/files/documents/2019/06/03/i.copan_.-vcat_060419-corrected.v2.pdf, and a summary of the key points is provided.

In the budget overview, Dr. Copan mentioned that there is approximately a 33 percent reduction in the FY 2020 budget from the enacted FY 2019 budget. The President's FY 2020 budget request:

- Prioritizes NIST's core measurement science mission;
- Prioritizes support for NIST's role in quantum science, artificial intelligence, and microelectronics-related Research and Development (R&D);
- Eliminates funding for MEP (Manufacturing Extension Partnership); and
- Supports NIST's Boulder Building 1 project (through GSA Federal Capital Revolving Fund.

Dr. Copan next highlighted a number of key programmatic achievements that had taken place over the past several months including:

- The historic redefinition of the International System of Units (SI). In November 2018 a vote took place to redefine the SI units based on the fundamental constants of nature, and on May 20, 2019, on the World Metrology Day, the new system went into effect. Four of the seven base units of the SI have been redefined due to the replacement of the artifactual kilogram.
- Dr. Copan thanked all that contributed on the review of the Return on Investment Final Green Paper and stated that it was published April 24, 2019, as the NIST Publication 1234. Dr. Copan laid out plans for further community engagement and the development of actions to address the findings laid out in the Green Paper.
- Dr. Copan highlighted several of the technical break throughs NIST has achieved in precision measurement including the demonstration of the latest generation atomic clock which uses the frequency comb technology and operates based on the vibrations or "ticks" of the rubidium atom. This next generation atomic clock is one of the NIST-on-a-Chip technology commercialization efforts that NIST is looking to advance with commercial and academic partners.
- In the area of advanced manufacturing, Dr. Copan mentioned several NIST activities. NIST's leadership role in Manufacturing USA provides strong coordination with Department of Energy (DoE), Department of Defense (DoD), and Department of Commerce (DoC). DoE announced there is a new DoE Cybersecurity Institute for Energy Efficient Manufacturing. NIST will closely connect with the

work ongoing across other institutes of the Manufacturing USA network, working on cybersecurity and securing the smart grid. Another NIST effort in the area of advanced manufacturing is Manufacturing Extension Program (MEP). MEP continues to have positive outcomes in the U.S. economy in terms of jobs, growth in GDP (gross domestic product), industrial output, and ROI (return on investment). Dr. Copan plans to meet with the leadership of the MEP national network in Pittsburgh area.

- NIST's 5G and Beyond program is providing industry with robust metrology tools and data. NIST also has a Public Safety Innovation Accelerator Program, and the new awardee is Spectronn, who developed a mobile edge computing-in-a-box system. Active engagement with other agencies and the private sector on 5G standards is ongoing.
- In the area of cybersecurity and privacy issue, Dr. Copan provided an update about the second phase of evaluation and review of the algorithm candidates for post quantum cryptographic standards; the review is in progress and will last 12 to 18 months. Out of the initial submission of over 50 algorithm candidates, 26 algorithms have been down-selected based on performance to the next post-quantum crypto semifinal round. The goal is to continue to advance the evaluation effort as rapidly as possible resulting in a couple quantum-resistant algorithms ready by 2022. In the interim, there have been a series of guidance documents that relate to cybersecurity in the current environment. For example, a Roadmap for the Cybersecurity Framework Version 1.1 was issued the end of April. NIST is delighted with the continued work on the cybersecurity for the Internet of Things (IoT) that is ongoing, including the core cybersecurity capabilities baseline discussion draft that was issued in the beginning of February.
- In Artificial Intelligence Dr. Copan stated that NIST is developing a plan for federal engagement due to the Executive Order issued February 11, 2019: *Maintaining American Leadership in Artificial Intelligence*. Efforts include development of tools for measurement and assessment of trustworthy AI, and a workshop to solicit input for federal engagement in AI standards development. NIST has put out a request for information and has hosted a workshop on May 30th to gather stakeholder input.

Dr. Copan next addressed the issue of science and security and the steps that NIST is taking to enhance security at the agency, NIST engages in a wide variety of ways with domestic and international partners. Dr. Copan mentioned a recent high-level meeting at the National Academies with the National Science and Technology Council Principals group, focusing on high profile breaches of the peer review process that is utilized for program down-selection and for grant distribution. It is important for NIST to work closely with the DoC Office of Security on background checks before report on duty, in order to protect the results of U.S. intellectual property. Dr. Copan praised NIST staff for embracing the importance of security. The safety record remains strong, and NIST is continuing the installation of cypher locks at laboratory facilities.

An important issue for the future health of NIST is that of improving equity, diversity, and inclusion across the institution. Dr. Copan outlined his goal to continue to build a culture of diversity and inclusivity at all levels of the NIST organization and the steps NIST is taking to achieve that goal. Dr. Copan mentioned Freeman Hrabowski, President of the University of Maryland, Baltimore County, gave an inspiring speech at the first Inclusivity Summit, which was made available on the NIST website via the NIST Tube. NIST has also launched an external assessment of equity disparity in NIST STEM career advancement and is taking steps to improve the diversity of our recruitment pipelines.

When discussing plans for the future, Dr. Copan stated plans to create a new senior executive role, a Director of Technology Transfer, which will have responsibilities for internal as well as national technology transfer programs; a Chief Human Capital Officer to look more broadly at human capital elements; and a Director of Strategy and Policy to incorporate the Program Coordination Office. Dr. Copan also mentioned the plans for other realignments within the organization.

Discussion:

The group discussed the following topics:

- MEP program funding support;
- User facilities at NIST in nanosciences, measurement sciences, and neutron scattering;
- Modernization of databases and tools via the Formational Technology Discovery Office; and
- A technology concierge model across academia and Federal sector.

For more information, see Dr. Copan's presentation.

SESSION II: ADMINISTRATION'S PRIRITIES FOR SCIENCE AND TECHNOLOGY

Overview of the Administration's Priorities for Science and Technology - *Dr. Jason Boehm, Director of NIST Program Coordination Office*

Dr. Copan introduced Dr. Boehm who replaced Dr. Kelvin Droegemeier to provide some background information on strategic planning. Dr. Boehm began his talk with a video presentation about NIST-on-a-Chip program, and why NIST is the right place for the NIST-on-a-Chip development to take place.

Dr. Boehm then gave an outline on the Administration's science and technology priorities, which have a very strong focus on security, namely making sure the United States is leading in key emerging technologies and that the country is putting in the policies to protect those advantages:

- AI, quantum, and computing
- Connectivity and autonomy
- Supporting advanced manufacturing
- Leader in space and building commercial space industry
- Energy dominance
- Driving medical innovation
- Advancing U.S. agriculture

Dr. Boehm emphasized the Administration further doubled-down on some of these technology areas, such as advanced communications and continuing to move beyond 5G. The Administration sees a strong industry focus, partnering with industry, taking advantage of capabilities if industry and academia, targeting investments in the workforce. Another strong focus of the Administration is reducing government barriers, i.e., reducing regulation and limiting regulatory burden. There is also a strong national security focus. Even though NIST is a civilian sector agency, the bulk of work focuses on civilian applications and industrial applications, with a strong national security implication, which is reflected in the FY 2020 budget.

Though there is a 30 percent reduction in the budget for FY 2020, Dr. Boehm stated the Administration recognizes the key role NIST must play in key areas. The budget cut will require NIST to redirect resources internally to the priorities the Administration has outlined. With the Administration reducing non-defense discretionary spending, these cuts have created extra challenges for civilian science agencies, like NIST.

Discussion:

The group discussed the following topics:

- Focus on areas of fundamental research that will bring new discoveries;
- 5G activities, including fundamental standards testbeds, developing industry consortiums;
- 28 GHz compatibility in the future;
- Flexibility to design programs, given existing resources, on AI and quantum;
- Difference between artificial intelligence and advanced machine learning; and
- Challenges addressed by NIST manufacturing networks.

SESSION III: NIST STRATEGIC PLAN – POSITIONING FOR A CHANGING S&T ENVIRONMENT

NIST Strategic Planning Overview - *Dr. Jason Boehm, Director of NIST Program Coordination Office*

Dr. Boehm began the presentation by explaining the motivation for the NIST Strategic Plan that include:

- Technological Changes;
- New Business Models;
- Aging Infrastructure;
- Changing Expectations;
- Outdate Processes; and
- Limited Resources.

Three assessments were used to lay the foundation for the Strategic Plan. First, an analysis was conducted across the agency which requested staff input on what they saw as major strengths, weaknesses, opportunities, and threats (SWOT). Second, a Baldridge organizational profile was developed for the agency, which helped to shape a vision moving forward. Third, an environmental scan was conducted to identify external drivers and trends.

From the environmental scan, changing demographics is a big issue ahead for NIST. Dr. Boehm stated this could cause barriers and challenges in bringing in technical workforce. There is a high demand for a limited workforce not just in industry but also in government in areas like artificial intelligence, quantum science, and advanced communications.

In addition to workforce challenges, the current budget process creates new uncertainties. NIST must be ready to respond to the political and policy issues. A good baseline for leadership to look at is the SWOT analysis. The Program Coordination Office (PCO) led seven sessions from staff all across NIST at different levels, e.g., division chiefs from the laboratories and programmatic organizational units, division chiefs from Management Resource and the Director's office, members of the Operations Advisory Committee, members of a recent Foundations of Leadership class, former rotators of the PCO, NIST Fellows, and a sampling of Boulder staff. This exercise generated over 469 different comments and inputs. The SWOT results reinforce many opinions about what makes NIST successful, while the biggest challenges lie in how NIST does its research and how it partners and delivers services. One universal theme that came out of the SWOT analysis is NIST's organizational structure, including challenges with communication and leadership weaknesses.

Following the foundational work for the Strategic Plan, NIST Leadership Board met and determined the four Strategic Plan Goals:

Goal 1. Position NIST to advance U.S. science and innovation;
Goal 2. Maximize NIST's stakeholder impact through high-value service delivery;
Goal 3. Create the infrastructure for a 21st century research institution; and
Goal 4. Build a One NIST culture.

Dr. Boehm gave an overview of the NIST goals and four goal teams:

Dr. Jim Olthoff, Associate Director for Laboratory Programs, is leading Goal Team 1. This team has developed three objectives. First objective is to increase agility, promote collaboration, maintain technical excellent to strategically advance emerging technologies, and address national needs. The second objective is to develop and leverage flexible approaches to attract, retain, retrain, and grow talent in critical areas and adapt to demographics and expectations of the changing workforce. The third objective is to develop creative models that strategically expand external engagement and impact, aligned with the mission to maximize the value of the technical program.

Dr. Phil Singerman, Associate Director for Innovation & Industry Services, is leading the effort on Goal Team 2. This will include facilitating the transfer of NIST knowledge, inventions, and technologies from the laboratory to the marketplace. It is important to provide high-quality, integrated, and modern service delivery models. Stakeholders can readily identify and share NIST's priorities, capabilities, and value by strategically communicating the key messages.

Mr. Del Brockett, Associate Director for Management Resources, is leading Goal Team 3. This team is working on creating the infrastructure for a 21st century research institution. It will develop and implement plans for major facility upgrades, upgrade NIST's IT infrastructure, adopt and transition to modern business systems and operational practices to improve transparency and agility in research,

service delivery, and business operations during uncertain times.

Mr. Kevin Kimball, Chief of Staff, is leading Goal Team 4. This team is driving the effort on how to build a One NIST culture. The team is focused on developing and institutionalizing strong leadership and management competencies to advance the One NIST culture. This can be accomplished by creating an engaged, agile, and inclusive NIST workforce, strengthen NIST's workplace environment, and attract and retain a diverse and inclusive workforce reflective of the Nation.

Dr. Boehm, who is part of Goal Team 4, then gave examples of why NIST should be a 'branded house' and not a 'house of brands'. For example, there is confusion that MEP and the NIST Cloud Computing Program belong to One NIST as a whole. Ideally NIST wants to move to a branded house like FedEx with different business lines and different models; another example is the National Institute of Health and Oak Ridge National Laboratories. This is an area that requires further development of NIST as a brand.

Lastly, Dr. Boehm mentioned the work that is ongoing by the Enterprise Risk Management Office to communicate NIST priorities to internal and external stakeholders and help drive change within NIST moving toward.

Discussion:

The group discussed the following topics:

- Rapid-pulse type of data gathering, a useful tool for implementation;
- Areas NIST should focus on to lead with respect to technology;
- Difficulties transitioning new technologies and programs into the marketplace;
- Retention of employees in today's culture;
- Renewed sensitivity about technology transfer with international partners;
- Giving advice to NIST Director to be as open as possible on a global scale;
- Modernization of infrastructure with existing budget constraints;
- Difficulties of branding NIST components of service and technology;
- Branding must communicate and include emotion; and
- Brand ambassadors promoting the NIST brand.

For more information, see Dr. Boehm's presentation.

SESSION IV: UPDATE ON NIST ACTIVITIES IN EMERGING TECHNOLOGIES

Overview of the Executive Order on Maintaining American Leadership in Artificial Intelligence - *Dr. Lynne Parker, Assistant Director for Artificial Intelligence, Office of Science and Technology Policy*

Dr. Parker began her presentation by reiterating statement from previous speakers that AI is an important topic and is a priority area for this Administration; the White House remains committed to continued U.S. leadership in AI and ensuring AI benefits the American people and reflects American values. The President issued an Executive Order on February 11, 2019, *Maintaining American Leadership in Artificial Intelligence*, which establishes the American AI Initiative to promote and protect national AI technology and innovation. A White House *AI for American Industry Summit* was held in May 2018 bringing together over 100 stakeholders from industry, government, and academia. The AI Summit defined key directions reflected in the President's Executive Order.

Dr. Parker described the six primary goals outlined in the Executive Order:

- Prioritize AI R&D;
- Remove barriers to innovation;
- Ensure AI-ready workforce;
- Lead international AI deliberations;
- Leverage AI for government; and

- Defend national security.

When discussing innovation ecosystem for AI in America, Dr. Parker recalled a finding from the 2016 National Academies of Sciences, Engineering, and Medicine study, *Continuing Innovation in Information Technology, that* long-term federal investment leads to commercial industries. The innovation ecosystem requires tight coupling and tight operation of the federal government, industry, and academia. This combination will make the U.S. innovation ecosystem strong, and therefore the federal government is playing its role in supporting this endeavor, both the academic side and the industry side.

Dr. Parker highlighted the fact that AI R&D is one of the priorities outlined in the OMB/OSTP R&D budget priorities memo and that OSTP is taking steps to coordinate AI R&D across the Government. A key element of this coordination effort is the creation of the . Select Committee on AI, consisting of Secretary-level senior leaders. Dr. Copan is on the committee, along with France Cordova from the National Science Foundation (NSF) and Steven Walker from Defense Advanced Research Projects Agency (DARPA). The Select Committee meets several times a year to coordinate AI activities in federal agencies. Dr. Parker stated there is also a Machine Learning and AI Subcommittee, which is the operational arms of the Select Committee. This subcommittee is working hard to deliver on the actions called for in the Executive Order. Dr. Chuck Romine from NIST, Jim Kurose from NSF, and Steve Bentley from the Department of Energy (DoE), and herself co-chair this subcommittee. The goal is to help implement strategic priorities and the tasks directed from the Select Committee. There is also the Interagency Working Group that assists in coordinating these activities. This group consists of people that are experts in AI and machine learning.

Dr. Parker then discussed the National AI R&D Strategic Plan. The Plan is in the process of being refreshed after it was first generated in 2016. This effort will ensure that the US leads in the cutting-edge AI innovation.

On the topic of removing barriers to AI innovation, Dr. Parker gave examples of specific AI technologies such as driverless vehicles, drones, and tools that are providing health care services that are not consistent with current regulatory approach. Therefore, government regulations need to be modernized to be supportive of AI innovation. She also mentioned that Chuck Romine testified on proper use of facial recognition in law enforcement and what NIST's role is in facial recognition for law enforcement applications. For that reason, AI Executive order discussed AI guidance for federal agencies. The American AI Initiative directs OMB/OIRA (Office of Information and Regulatory Affairs) with OSTP and others to issue an oversight memo to heads of all agencies, that informs development of regulatory and non-regulatory approaches to AI, and consider ways to reduce barriers to the use of AI to promote innovative uses while protecting civil liberties, privacy, American values, and U.S. economic and national security. A draft version of the memo will be published for public comment.

While discussing the issue of educating and training AI-ready workforce, Dr. Parker stressed the need to build up the pipelines of people who are skilled and interested to work in these areas. The Executive Order calls for agencies to provide recommendations to prioritize existing programs that help provide people with more opportunity to learn the necessary skills. The President started the National Council for the American Worker to team up with industry to provide educational opportunities and training in AI. The Executive Order directs the Select Committee to provide recommendations on how to provide more AI relevant opportunities. Workforce challenges are critically important to ensuring the nation’s economic competitiveness and national security.

Dr. Parker concluded the presentation with discussion of the international deliberations that are ongoing in the AI arena. On May 22nd the Organization for Economic Cooperation and Development approved the historic international consensus statement on the AI principles – 36-member countries and 6-non-member countries agreed on the final language for the draft AI recommendation. The recommendation contains two groups of principals, and between the groups there are common issues such as fairness and transparency as well as what the national governments should do to move these principles along.

Discussion:

The group discussed the following topics:

- OSTP website on AI.gov to find out more information;
- AI strategy ongoing in Finland and lessons learned that may be available;
- Tensor processing units (TPU) widely available through the cloud; and
- Openness in sharing information on international basis

For more information, see Dr. Parker's presentation.

Update on the Development of the Federal Strategy for Engagement in AI Standards Development - *Dr. Charles (Chuck) Romine, Director, NIST Information Technology Laboratory*

Dr. Romine gave an overview of ITL's work in AI and machine learning and highlighted their efforts towards the development of a Federal Strategy for Engagement in AI Standards Development as called for by the Executive Order. The Executive Order specifically called out NIST to develop a plan for the Federal engagement in AI standards. NIST is tasked with developing a plan for Federal engagement in the development of technical standards and related tools in support of reliable, robust, and trustworthy systems that use AI technologies. NIST's efforts will support the development of standards for AI that reflect Federal priorities for innovation, public trust, and confidence. A workshop on this topic was held at NIST; Dr. Copan issued opening remarks that set the stage for an outstanding workshop. The workshop was to engage both private and public-sector organizations with the goal of having annotated outline of the report by the end of the workshop. The format of the workshop had two panel sessions and a set of breakout sessions. The workshop had participation from people on-site as well as WebEx. There were 217 attendees representing more than 100 different entities. The goal is to have the draft plan on Federal engagement for public comment in late June. An RFI went out in early May; the RFI called for comments on three topic areas: current-status and plans, needs and challenges, and role of Federal agencies.

Discussion:

The group discussed the following topics:

- Autonomy of software and AI as it applies to IoT;
- Obtaining lessons learned from Silicon Valley in the AI arena;
- Autonomous cars and Trusted AI;
- Difficulty in understanding multilayer neural networks;
- Role of simulation;
- Compatibility of systems on a global scale;
- In-memory intrusions and circuit board micro attacks; and
- Monitoring the performance of an engineering system to stay in nominal range.

For more information, see Dr. Romine's presentation.

Update on NIST Activities in Support of the National Quantum Initiative - *Dr. Carl Williams, Acting Director, NIST Physical Measurement Laboratory*

Dr. Williams presented an update on NIST and the NQI (National Quantum Initiative). Last summer, House introduced H.R. 6227, the National Quantum Initiative Act, which was passed unanimously in both the House and Senate. It was signed by the President on December 21, 2018. The bill has three broad requirements. Section 102, directs to establish the National Quantum Coordination Office, headed by the interim Director, Jacob Taylor. There are now four people in the Coordination Office, currently located within OSTP. Section 103 of the bill requires the existence of the Subcommittee on Quantum Information Science. This committee was previously established under the National Science and Technology Council (NSTC). Dr. Williams said he has been delegated the responsibility to be chair of this subcommittee. Section 104 asks that the National Quantum

Initiative Advisory Committee be set up as a FACA (Federal Advisory Committee Act) Committee by DOE. They will work closely with OSTP to ensure it is fair and balanced and represents the agencies.

Dr. Williams gave few examples of actions that were taken to advance a national strategy on Quantum Information Science (QIS). On September 23, 2018, OSTP and NSTC released a new national strategy for the Quantum Information Science, consistent with the NQI Act. On September 24, 2018, OSTP held a Summit on Advancing American Leadership. Closing remarks were given by Lamar Smith, who was a sponsor of the NIQ Act. On May 31, 2019, OSTP held an Academic Roundtable on Innovation in QIS.

The NIST section of the NQI calls for four goals:

- Continue and expand basic and applied R&D;
- Use the existing programs of NIST to train scientists in quantum information science and technology;
- Establish or expand collaboration ventures or consortia to advance the field of quantum information science and engineering; and
- Enter into contracts, CRADAs (cooperative research and development arrangements), grants and cooperative agreements in furtherance of the purposes of the Act.

Dr. Williams then pointed out that it is important to understand what it takes to build a quantum industry and the supporting ecosystem. Dr. Williams explained this using the example of the birth and evolution of the first transistor from 1947 to today's modern 2018 integrated circuit. Building out the infrastructure for future development is something that is going to take time. NIST has begun working with SRI International under a CRADA (Cooperative Research and Development Agreement). The primary focus is on three technical readiness levels (TRL), 3 to 5.

The Quantum Economic Development Consortium (QED-C) will support enabling technology R&D and enhance the quantum ecosystem. Some of the objectives are to facilitate industry coordination and interaction with government agencies, determine workforce needs, provide efficient public-private sector coordination, identify technology solutions, highlight use cases and grand challenges, and foster sharing of international property. The first meeting of the QED-C was held August 21, 2018, at SRI International; the second on October 29-30, 2018, at NIST in Boulder; the third on January 22-23, 2019, at Colorado University in Boulder; and the fourth held at NIST in Gaithersburg on April 30-May 1, 2019. A participation agreement will be set up and in place by fall of 2019. Currently, there are more than 60 letters of intent from companies to join the consortium.

Dr. Williams stated that there are three coordinated efforts that will fulfill NIST's mission in QIS. These are foundational research emphasizing QIS and metrology, applied research to engineer and improve robustness of prototypes, and realization and dissemination of units of measure. Dr. Williams spoke about one concept for a NIST Grand Challenge, which would cut across three areas: quantum SI, foundation of quantum science, and the quantum engineering. the challenge is to build a prototype 2-3 node Quantum Network that distributes, stores, and entangles states of matter for sufficient time to support R&D, sensing, and metrology using various technologies, e.g., long baseline entangled clocks. The prototype requires quantum memory, quantum repeaters, small quantum processors, transduction, quantum error correction, and entanglement purification. It provides a testbed for system components and standards and supports basic R&D. It allows development of improved components, entanglement of distant clocks or sensors, exploration of quantum enhanced long baseline interferometry. The bottom line is this prototype is a testbed for understanding where NIST can go.

Discussion:

The group discussed the following topics:

- Development of technology for quantum computing, similar to transistor development; and
- Software-related elements that make quantum computing useful.

For more information, see Dr. William's presentation.

SESSION V: UPDATE ON NIST LAB-TO-MARKET ACTIVITIES

Unleashing American Innovation- Next Steps – *Dr. Walter Copan, Under Secretary of Commerce for Standards and Technology and NIST Director*

Dr. Copan shared some viewpoints on next steps for technology transfer and U.S. innovation. Working closely with the White House, NIST has a unique role in promoting and reporting on the overall strength of the Federal technology transfer efforts. This is one of the areas of policy oversight that NIST has.
The ROI Green Paper outlines several strategies: identifying and addressing the regulatory impediments, making it easier to build consortia, and utilizing more flexible tools; creating incentives to engage investors and private sector, building a more entrepreneurial workforce; bringing innovative tools and services into practice; and assessing where we stand as a nation on a global scale.

After the publication of the ROI final Green Paper, Dr. Copan discussed the next steps. A top priority is the development of a legislative and regulatory reform agenda for interagency review and clearance. This work is already underway – the feedback from the industry is being shared with relevant agencies, and the policy framework is being shared with the industry for their buy-in. The recommendations included the work of the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, who have been recognized as an important tool for U.S. innovation and public-private engagement.

Dr. Copan then discussed how ROI findings address cross agency priority (CAP) goals strategies. On the topic of regulatory and administrative barriers, the issue of copyright protection for software is very important. This assures integrity and open-source use, which may provide opportunities to commercialize with the appropriate protections. And although federal institutions are able to patent, copyright protections under the government use provisions are not available. This is an area that NIST is working on with the Federal interagency, the United States Patent and Trademark Office. On the topic of private sector engagement, streamlining partnership agreements is an area that needs to be strengthened. This is important to NIST and other parts of the Federal sector to be able to use not-for-profit foundations. This will allow for new funding sources and new flexible arrangements to be curated. Regarding workforce, Dr. Copan explained that building a culture of an entrepreneurial workforce, utilizing some of the tools and best practices is needed, such as the I-Corps program pioneered by NSF. Part of the modernization also involves better management of conflicts of interest. This will enable engagement with industry more effectively with entrepreneurial enterprise and is an important part of building and changing culture for the future impacts from the Federal R&D system.

In conclusion, Dr. Copan said the VCAT will be working in the future with Kathy Ku, the chair of the Subcommittee on Technology Transfer, on a follow-on charter. This is aimed at asking members to review how NIST is doing with the technology transfer approach, overall performance, and areas that may need to be improved to enhance impact.

Discussion:

The group discussed the following topics:

- Where the Green Paper goes now;
- Who has access to the Green Paper; and
- How will this have effect.

For more information, see Dr. Copan's presentation.

Wednesday, June 5, 2019

SESSION VI: APS PERSPECTIVES & NCNR OVERVIEW

APS Neutron Perspectives – Global & Domestic Context - *Dr. Julia Phillips, American Physical Society*

Dr. Phillips presented the American Physical Society (APS) study, *Neutrons for the Nation*. It was predated by a National Academy study which raised awareness regarding neutron scattering around the world. The *Neutrons for the Nation* was done by an eminent committee consisting of luminaries in the field of neutron science.

The report motivation was aimed for a general policy-oriented audience to first, describe the importance of neutron sources in various areas for the foreseeable future; second, to illustrate the importance of neutron sources produced today and how they might be produced in the future; third, how can the U.S. be a global player in neutron science; and fourth, what policy issues need to be considered in designing and building future neutron sources.

The first conclusion reached was that neutrons are extremely important for science, engineering, and industry. The physics of the neutron and the ability to measure the lifetime of the neutron has gotten good enough that the error bars have shrunk. It is now known that there is a discrepancy in the lifetime of the neutron that's measured using two different techniques. Being able to test materials in environments that mimic the environments they are going to see for decades is very important. A key finding of the study – investigations performed at neutron sources are essential components of R&D in numerous areas of science and engineering, and they also have a lot to contribute to industrial competitiveness.

Neutron scattering is an essential component of an ensemble of research techniques. Another key finding of the study is that neutron scattering is often an essential part of a broader experimental study that uses a complementary suite of tools. Dr. Phillips said NIST users and collaborators have done extraordinarily well in terms of advances in instrumentation at neutron sources.

One of the centerpieces of the report is that the neutron R&D in this country is vulnerable. In the U.S., there are six high-performance research reactors, NIST being the newest and it is 50 years old. There are 48 scattering beamlines in the United States, 153 in Europe, and 99 in Asia. Several facilities have been shut down in the U.S., while the rest of the world is continuing to build. The U.S. has lost important capability in neutron R&D in the last two decades and is no longer the world leader.

High-performance research reactors (HPRRs) are important for neutron research, development, and production and are especially suited for studies like materials testing in radiation environments, isotope production, and a capability to support many experiments. The challenge is that HPRRs in the U.S. are all fueled by highly enriched uranium (HEU) and HEU constitutes a proliferation risk. Therefore, U.S. policy dictates eliminating HEU in civilian applications wherever possible. Converting existing HPRRs to low-enriched uranium is not possible with existing fuel. Reactor fuels containing highly enriched uranium represent a risk for proliferation, which should be considered when planning for future infrastructure for neutron R&D.

World-class neutron R&D currently requires three things: spallation sources, which are pulse sources and are radiological facilities not neutron facilities; research reactors, which is important for materials testing; and high-performance instrumentation, that provide computing and data analytics, beamline instrumentation. World-class neutron science and engineering require the complementary capabilities of these three things to have a real world-class neutron capability.

The APS study recommends that the U.S. should do the following:

- Continue to support a diversity of neutron R&D capabilities;
- Find a balance in retaining and enhancing the capabilities and reducing or eliminating the use of HEU;
- Sharply increase investment in neutron instrumentation development and deployment;

- Reaffirm its commitment to the development and deployment of high-density, low enriched uranium (LEU) fuels for existing HPRRs; and
- Initiate an effort to competitively design and build a new generation of LEU fueled HPRRs.

Some areas for considerations moving forward that need further study are 1-the lead time for commissioning a new HPRR of any type is very long, 2-the development of very high-density LEU fuels appropriate for converting existing HPRRs has taken much longer than originally anticipated, and 3-the timeline has moved out repeatedly. Can all of the uses of HPRRs be met without the use of HEU and should all of the current uses of HPRRs be met in a single LEU-fueled HPRR? Are there other innovative approaches to satisfying all of the needs currently met by HEU-fueled HPRRs? Dr. Phillips gave several examples of what has not been met in this area.

In closing, Dr. Phillips mentioned one finding by the 2016 Academy study is that, unlike most of the light sources in the U.S., there is no single steward for a U.S. neutron capability, which is a disadvantage in terms of real planning for what the U.S. needs regarding neutrons. The recommendation at that time was that OSTP should convene the owners of neutron capabilities and those with needs for neutron capabilities in order to look across all of the government agencies and help devise a plan for U.S. neutrons for long-term investments of at least 50 years.

Discussion:

The group discussed the following topics:

- U.S. competitiveness on reactor capability and quality;
- Production of neutrons by plasma or a cascade effect;
- Bottleneck to U.S. competitiveness and whether more capacity is beneficial;
- Light sources not replacing x-ray diffraction for doing crystal structures;
- Need for small neutron sources where preliminary experiments can be done;
- Length and time scales using neutrons to explore physical properties;
- Looking at ROI to find out which applications are worth investing in;
- LEU versus HEU, confluence between science and security concerns;
- Best locale for a new LEU meeting the needs of the U.S.; and
- Location of and number of reactors needed for security posture and education in U.S.

For more information, see Dr. Phillips' presentation.

NCNR (NIST Center for Neutron Research) Overview - *Dr. Rob Dimeo, Director, NIST Center for Neutron Research*

Dr. Dimeo stated there is an ongoing lag in neutron scattering research in the U.S. compared to the world, resulting in an issue of international competitiveness. NIST is an essential part of U.S. neutron measurement infrastructure, and a robust aging reactor management program is needed to address reliability issues at NIST. Looking at a new high-performance LEU-based research reactor is worth exploring. His presentation covered four main points:

- NIST mission – developing neutron measurements and making them available to the scientific community is central to the NIST mission;
- A major national user facility – research quantities of neutrons can only be produced at major, centralized facilities;
- Delivering high impact – NIST continues to be a source of excellent science with neutrons; and
- Building for the future – NIST's neutron measurement capabilities continue to improve.

The mission of NCNR is to make neutron measurement capabilities available to the U.S. scientific community. This is accomplished in three ways:

- Operate reactors safely and cost effectively;
- Develop new neutron measurement capabilities and apply them to problems of national interest; and
- Serve the needs of researchers from industry, academia, and government as a national user facility.

Neutrons that are made in a nuclear reactor are quantum particles with a wavelength which is on the same order as the interatomic distances in condensed matter. This allows one to probe the structure of matter with neutrons. Further, energies of neutrons allow to probe the energy of condensed matter systems, measuring things like phonons, acoustic waves, and floppy motions of macromolecular systems. Neutrons are highly penetrating. The power of neutrons lies in the contrast, as one can better see with neutrons than x-rays, photons, electron beams, and other probing techniques.

Another feature of neutron application is magnetism. The neutron has a magnetic moment, which means one can actually "see" magnetic structure, the structure of solids that are magnetic at the atomic scale. This has a big impact for metrology of next-generation information technology. Dr. Dimeo gave some examples of the power of neutrons. Julia Cornfield tested different types of jet fuel additives to make safer jet fuel, partnering with the Physical Measurements Laboratory looking at the radiated decay of a neutron. Ron Bishop performed an analysis of pottery by doing sensitive chemical composition measurements and discovered that original formulation of the Mayan trade routes was incorrect. Mas Subramanian discovered new pigments using ultra-small-angle neutron scattering on porous shale. Young Lee measured a solid called herbertsmithite and discovered quantum-spin liquid, which provides possibilities in quantum information science.

Dr. Dimeo then discussed instrument ownership and access. There are two ways that NIST has instrument ownership, NIST-owned and partnership-owned. Instrument access is based on general user access, collaborative access, consortium-based access, partnership-based access, and proprietary access. There is no charge for users to use neutron capabilities at NCNR except in instances of consortia and proprietary based and in those instances if they publish in the open literature, they pay full-cost recovery.

Regarding user engagement, NCNR management frequently gathers feedback from users on-site via discussions and post-experiment surveys. NCNR hosts occasional workshops to gather input from the user community on future neutron-scattering instruments. NCNR staff and leadership engage with the user community at scientific meetings and other venues. The Beam Time Allocation Committee convenes twice a year at NCNR and is another mechanism to get feedback.

The NIST reactor is regulated by Nuclear Regulatory Commission (NRC) and licensed through 2029, and NIST fully intends to transition from HEU to LEU when it becomes available, currently scheduled for the late 2020s. There are several committees that are independent groups that review the safety aspects of the reactor operations.

The total appropriation for the budget is about $48 million, with about $3 million from other agencies. A quarter of the operations goes to operating the reactor. Half is going towards scientific operations, operating and maintaining the beamlines. About 15 percent goes to research facility development, which includes upgrades and development of new auxiliary equipment. The only way for a national user facility to be competitive is to keep developing the state-of-the-art capabilities.

Partnerships are a key way to expand the research community's access to NIST's neutron capabilities and benefit the U.S. scientific enterprise. This includes not just user support, but also education and outreach. NIST continues to be a source of excellence science with neutrons. Dr. Dimeo provided examples of different partnerships.

The Canadian Neutron Beam Center conducted a study of bibliometric record to capture the outcomes and achievements of networks of collaborators from 1980 to 2017. It contextualized the activities through a comparison of three Canadian and five international benchmark institutions, which provide points of reference. They concluded that NCNR came in first by a wide margin for all indicators and is the only institution examined that had consistently high performance among all the indicators. Building for the future, NIST's neutron measurement capabilities continue to improve.

In closing, Dr. Dimeo stated a lot has happened in the last 17 years. The U.S. has basically the spallation neutron source and the NCNR being built out and expanding capabilities; however, China continues to increase their capabilities with three new operations, though they have not yet been fully instrumented. A study was conducted in 2017 and reported the future options for the neutron source at the NCNR would be to 1-maintain

the National Bureau of Standards Reactor (NBSR) in current configuration, 2-major upgrade to the NBSR to enhance flux, and 3-replace the NBSR with a new reactor.

Discussion:

The group discussed the following topics:

- Managing oversubscription of users;
- Neutron guides operating like fiber optics;
- Instruments get shut down to make room for new ones;
- Industrial impact from different consortia and user communities;
- NIST's capabilities to solve Boeing 787 battery problem example of why reactor at NIST is crucial;
- Cross-cutting plan or committee to discuss neutron sources and who is building what;
- NIST being the commercial interface between DoD and DoE;
- The amount of funding needs to do the optimum work, requesting it in stages;
- Neutrons versus x-rays with photons for measurements; and
- LEU reactor capabilities and need for new facilities.

For more information, see Dr. Dimeo's presentation.

nSoft Consortium-Industry Impacts on Development of Neutron-Based Measurement Science - *Dr. Ron Jones, Director, nSoft Consortium, NIST Material Measurement Laboratory*

Dr. Jones started his presentation by describing that nSoft Consortium is trying to solve the problem of industry's access to national research facilities – these facilities see industry as a key customer and industry needs these facilities to innovate, however, access models of these facilities are geared toward academia by allocating access free of charge, based on merit as determined by peer review. nSoft Consortium is using cost recovery model, where access is granted to the partner company on paid basis.

Another way to think about nSoft is as an incubator. An incubator has a different access model – there are no proposals and the merit of the problem is determined by the customer; there are also different metrics for success, for example, instead of quantity and impact of publications, success is related to the impact in the company. The goals here is to achieve an impact within the member company and advance the NIST mission simultaneously. Finally, this is a totally nonproprietary environment. There is never a proprietary experiment done within nSoft. Dr. Jones explained that what they have done is create a model where they are pairing industrial needs with NIST-driven experiments that create a new measurement capability. Another benefit is the expertise transfer: it's a place to learn, a place to influence development, and a place for NIST to advance its mission.

Most of the members are Fortune 100 companies because they need to have a research and development staff as well as an appetite for long-term research projects; however, small companies are not excluded, and anyone is welcome. Members must be able to participate in on-site experiments, and the cost is $25,000 a year. There is expanding support across the NIST campus, and nSoft is a NCNR-centric activity.

Dr. Jones gave a few examples of nSoft activities. First was high shear in manufacturing. Rheology is an areas of core competency not only at NCNR but also across NIST. In this experiment, soft material is exposed to force that is precisely measured, and the response of the material – its structural changes – is measured on the molecular level. Information can be put into models of rheology and turned into a better understanding of what is happening to a system during manufacturing.

Another example of a nSoft activity was efficient shale gas extraction, which won an award. There is a need to understand gas storage in shale. This project used neutron imaging and neutron scattering. The neutron imaging was combined with x-ray imaging capability and provided a simultaneous tomogram of the shale core straight out of the ground.

Lastly, Dr. Jones described ongoing work with Pfizer Consumer Healthcare on Advil and Emergen-C vitamins looking for soft-gel cap formulations, however, there is a broader effort. There is a biomanufacturing effort across NIST to look at characterization of advanced therapeutics. New product formulations are in the pipeline and are being tested for adoption.

Discussion:

The group discussed the following topics:

- Increasing amount of data generated from various experiments in a searchable format with results;
- Applying machine learning techniques to smaller datasets;
- Is nSoft model replicable to other user centers in other parts of the government; and
- Instrumentation built at nSoft and is available to the public.

For more information, see Dr. Jones' presentation.

Panel Discussion – Customer Viewpoints on NCNR Facility Use - *Dr. Despina Louca, University of Virginia; Dr. Young Lee, Stanford University; Dr. Hubert King, ExxonMobil Research; Dr. Norman Wagner, University of Delaware; and Dr. Michael Hore, Case Western Reserve University*

Dr. Dimeo stated that the customer viewpoint panel consisted of users of the NCNR who were here to share their knowledge and experience using the facility and answer questions from the VCAT members. Next was a brief introduction of each panel member.

Dr. Hore came to NIST through summer school and then as an NRC postdoc and said everything he knows about neutron scattering, he learned at NCNR. His research area of interest is nanoparticles, typically spherical ones. There used to be theories about what polymer chains looked like due to indirect measurements of the shape, but neutrons have enabled the measurement of polymer chains today. Looking at the dynamics, one can determine the length scales over which the polymer chains move. Also, the transport of nanoparticles through single nano channels is another area of interest. All these research areas are dependent on NCNR for measurements.

Dr. Louca first came to NCNR after she received a call from Brian Toby as a young assistant professor 20 years ago. Then John Copley suggested she come to NCNR to study a new oxide that she has developed using the Disk Chopper Spectrometer, which was just coming online. She began to collaborate with other groups from around the world and appreciated the unique experience she received at NCNR. NCNR sponsored her in the summer at the beginning of her career, where she interacted with others using spectrometers.

Dr. King a researcher from ExxonMobil has had good experiences with NCNR and gave examples of how Exxon Mobil has benefited from it. ExxonMobil has had a long relationship with NCNR, which started in the 1980s, beginning with scattering beamlines. The NCNR scattering facility was the premier method of doing this, and it produced an unprecedented resolution, where ExxonMobil applied it to polymers, metals, complex fluids, and rocks. NIST published a report in 2011 calling the relationship with ExxonMobil one of the most fruitful collaborations in neutron scattering history. The polymers for coal flow of diesel has been one of the great successes and has been publicized in the neutron community. Recent studies are targeting unconventional resources such as shale gas.

Dr. Wagner from University of Delaware started working with NCNR doing neutron scattering in complex fluids and polymers, which later became soft matter, and research in the neutron scattering ecosystem as a whole. Many of the graduate students and postdocs are funded through NIST, and some from other entities, like NSF. Many stayed at NIST and become scientists; others moved on to other universities, consumer product companies, and biopharmaceutical companies. Dr. Wagner mentioned that the students he works with at NCNR at this time are all female and they enjoy the working environment. The consortium that put together the standard monoclonal antibody has advanced with new techniques and research. The existing sample environment and instrumentation needs to be pushed to provide longer times in its spin echoes and a broader range of time in length scales.

Dr. Lee started doing neutron scattering research as a grad student at the Massachusetts Institute of Technology about 20 years ago, but halfway through his studies, the Brookhaven reactor shut down. Wanting to further his thesis as a postdoc, he came to NIST, which he attributes to saving his career. He believes the capabilities of neutron scattering at NIST are irreplaceable in physics research. He gave an example of quantum spin liquids as fundamental science. He also mentioned a crystal made of a mineral called herbertsmithite which has a quantum spin liquid state and was studied in an inelastic neutron scattering.

Dr. Colwell commended the panelists and asked if there were any events or things that could be improved or replaced to make it better. Dr. Louca stated that NIST was excellent in managing time under very stressful situations, due to a lack of funding, but if there was anything that could be improved, it would be to increase funding for NIST. Dr. Wagner stated that creating a larger beamline science community would help bring more neutron scattering research forward.

Another question for panelists stemmed around new users coming to use the facility and if there is a way to create a company, who would be paid by the user and not NIST dollars, whose job it is to help people who want to come in to design and execute the experiment, thinking here of removing some of the load from the staff here who have other work to do. Dr. Lee said part of the job of an instrument scientist is assisting users who have no experience with an instrument and experiments. nSoft provides a different type of service, more geared towards the expertise, transfer, and training industrial folks on using neutrons. Education and training are key, as it's in every performance plan of every instrument scientist at NCNR.

Several panelists agreed that there is a problem of instruments that are oversubscribed. There is a very solid user program, which benefits other DoE facilities.

One panelist stated to have a layer process bringing experts into use from a non-expert perspective would be beneficial.

A question was asked about the importance of the proximity of NIST compared to a facility that is remote and not as easy to get to. Dr. Hore stated that proximity of NIST is beneficial to him, and Dr. Louca agreed. Dr. Lee stated the having NIST in a metropolitan area attracts good scientists. He also stated that if a facility went down, it would have a negative impact on his research.

In closing, Dr. Colwell and Dr. Copan thanked everyone who participated in the meeting, especially all the panelists and speakers for their time and contributions.

There were no public comments offered.

Adjournment

The meeting was adjourned at 12:02 PM.
I hereby certify that to the best of my knowledge; the forgoing minutes are accurate and complete.

Stephanie Shaw, Designated Federal Officer, NIST Visiting Committee on Advanced Technology
Dr. Rita Colwell, Chair, NIST Visiting Committee on Advanced Technology