

VISITING COMMITTEE ON ADVANCED TECHNOLOGY
National Institute of Standards and Technology

2020 Annual Report

Visiting Committee on Advanced
Technology
of the
National Institute of Standards and
Technology

U.S. Department of Commerce

March 2021



Preface

The Visiting Committee on Advanced Technology (VCAT or the Committee) of the National Institute of Standards and Technology (NIST or the Institute) was established in its present form by the Omnibus Trade and Competitiveness Act of 1988 and updated by the America COMPETES Act in 2007 and the American Innovation and Competitiveness Act of 2017. The VCAT is a Federal Advisory Committee Act (FACA) committee and its charter includes reviewing and making recommendations regarding general policy for NIST, its organization, budget, and programs within the framework of applicable national policies as set forth by the president and the Congress. This 2020 annual report covers the period from March 2020 through February 2021.

The Committee reviews the Institute's strategic direction, performance and policies, and provides the Secretary of Commerce, Congress, and other stakeholders with information on the value and relevance of NIST's programs to the U.S. science and technology base and to the economy. At the first meeting of each year, the Director of NIST proposes areas of focus to the Committee and agreement is reached on a program for the year. Over the past year, the Committee has been active in assessing NIST's contributions to and progress in the following areas:

- NIST Role in the Innovation Ecosystem
 - NIST Efforts to Advance Emerging Technologies
 - NIST Support for U.S. Manufacturers
 - NIST Efforts to Enhance U.S. Technology Transfer
 - Evolving Strategic Context and Emerging Challenges
- NIST Efforts to Respond to COVID-19
- NIST Strategic Planning
- NIST Facilities and Infrastructure

The Committee reviews a significant portion of NIST programs through direct discussion with NIST leaders, scientists, and engineers. Reactions and observations of the Committee members are presented candidly to the NIST senior management and other attendees at each meeting. This feedback encourages continuous improvement in key areas in the overall operation. The Committee also visits various NIST laboratories and satellite facilities to discuss research projects directly with the technical staff. These laboratory tours help the Committee to assess the impact of NIST research, progress towards achieving research goals, the quality of the staff, institutional culture – especially related to safety and security – and the efficacy of the facility infrastructure.

Under the Committee charter, the Director of NIST appoints the VCAT members. Members are selected on a clear, standardized basis, in accordance with applicable Department of Commerce guidance. Members are selected solely on the basis of established records of distinguished service; provide representation of a cross-section of traditional and emerging U.S. industries; and are eminent in fields such as business, research, new product development, engineering, labor, education, management

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consulting, environment, and international relations. No employee of the Federal Government can serve as a member of the Committee. Members are appointed for staggered three-year terms.

During this reporting period, three VCAT members completed their two consecutive three-year terms: Dr. Rodney Brooks (Robust AI), Mr. Michael Garvey (M-7 Technologies), and Ms. Hemma Prafullchandra (Microsoft).

This report highlights the Committee's observations, findings and recommendations. Detailed meeting minutes and presentation materials are available on the NIST web site at www.nist.gov/director/vcat.

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VCAT Members during the Period Covered by this Report

Dr. Allen Adler, Chair
HRL Laboratories, LLC
Term: January 25, 2016 – January 24, 2022

Ms. Katharine Ku, Vice Chair
Wilson Sonsini Goodrich and Rosati
Term: May 22, 2018 – May 21, 2021

Mr. Jay Alexander
Keysight Technologies
Term: May 22, 2018 – May 21, 2021

Dr. Eric Kaler
University of Minnesota
Term: December 21, 2018 – December 20, 2021

Dr. Rodney Brooks
Robust AI
Term: June 1, 2014 – May 31, 2020

Dr. Mehmood Khan
PEPSICO
Term: November 13, 2018 – November 12, 2021

Dr. Vinton G. Cerf
Google
Term: December 21, 2018 – December 20, 2021

Ms. Hemma Prafullchandra
Microsoft
Term: October 27, 2014 – October 26, 2020

Mr. George Fischer
Verizon Enterprise Solutions
Term: May 22, 2018 – May 21, 2021

Dr. Theodore Sizer
Nokia Bell Labs
Term: August 28, 2015 – August 27, 2021

Mr. Michael Garvey
M-7 Technologies
Term: January 23, 2015 – January 22, 2021

Mr. David Vasko
Rockwell Automation
Term: February 2, 2017 – February 1, 2023

Dr. Waguih Ishak
Corning Incorporated
Term: January 25, 2016 – January 24, 2022

Dr. Gail Folena-Wasserman
AstraZeneca
Term: January 30, 2017 – January 29, 2023

Dr. Dana (Keoki) Jackson
Lockheed Martin
Term: May 22, 2018 – May 21, 2021

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Executive Summary

The VCAT appreciates the forthright and candid nature with which the NIST staff have engaged over the past year. NIST is playing a critical role in furthering national goals around the development and deployment of critical emerging technologies including artificial intelligence, quantum science, and advanced communications. NIST programs focused on manufacturing including the Manufacturing Extension Partnership, Manufacturing USA, and the research efforts of the NIST laboratories will be critical in supporting the post pandemic economic recovery. NIST has responded magnificently to the challenges posed by COVID-19 in the steps they have taken to protect their staff while continuing essential research, and in the way that the NIST community has rallied together to focus skills, resources, and capabilities to help combat the pandemic. NIST strategic planning efforts have provided the agency with a framework to drive important cultural change around issues like diversity and inclusion, collaboration, and leadership, while also ensuring that NIST is well positioned to meet the needs of its stakeholders. Despite so many positive contributions across such a broad portfolio of activities, NIST remains under resourced. Perhaps nowhere is this more painfully obvious than in the status of NIST's facilities where NIST currently has a deferred maintenance backlog of over \$800 million. Without sustained and stable investment, NIST faces an increased probability, which will approach near certainty, of catastrophic infrastructure failure which will escalate overall operational costs, decrease efficiency and lower productivity of the research laboratories, and could endanger the health and life safety of the NIST staff. The report provides further details of our deliberations and recommendations for NIST. The VCAT believes that the following issues deserve priority attention:

- NIST must be adequately resourced to meet the growing list of challenges that NIST is called upon to address—from supply chain security to advancing quantum science and trustworthy AI to strengthening U.S. engagement in international standards.
- The Manufacturing USA program and the Manufacturing Extension Partnership program should be sufficiently resource in order to play a significant role in strengthening the overall competitive posture of the U.S. and will certainly help accelerate post-pandemic economic recovery. Significant new investment in the NIST facilities must be part of any scientific research and development infrastructure initiative for the US to effectively compete with China and other global competitors the U.S. must have a vibrant infrastructure to support scientific research and development.
- NIST has made impressive strides in its strategic planning, leadership and the new leadership should continue ongoing efforts to strengthen NIST branding and external communications, along with its efforts to improve diversity, equity, and inclusion across the NIST workforce.

1. VCAT Focus in 2020

With the COVID-19 Pandemic raging across the world, 2020 was a unique year for the VCAT. Despite being forced to meet throughout the year virtually, the VCAT had very productive interactions with NIST leadership and scientists. In 2020, the VCAT focused their efforts on four major items:

- NIST's role in the innovation ecosystem (including NIST efforts to advance emerging technologies, support advanced manufacturing, and strengthen technology transfer);
- NIST's response to COVID-19;
- NIST efforts in strategic planning;
- Ongoing efforts to strengthen NIST infrastructure.

Additionally, the VCAT was briefed on the NIST Budget Outlook. The VCAT received detailed programmatic briefings in all these areas and met with key policy makers. This 2020 Annual report summarizes the VCAT's work, observations, and recommendations related to these topics.

2. NIST Role in the Innovation Ecosystem

NIST is playing an important role to enhance overall U.S. innovation and competitiveness. In 2020 the VCAT continued to focus on NIST's role in advancing important emerging technologies such as quantum science, artificial intelligence, and advanced communications. The VCAT reviewed NIST progress and programmatic plans, including important external partnerships, such as Centers of Excellence, Joint Institutes, consortia, and grant programs to name a few. In addition, the VCAT was updated on NIST's continuing efforts to advance and support work in advanced manufacturing as well as priorities and plans for Manufacturing USA and the Manufacturing Extension Partnership (MEP) Program. The VCAT also continued to track NIST efforts to strengthen and reform the policies governing technology transfer in the U.S., including ongoing efforts towards the implementation of the NIST Return on Investment Initiative (ROI), and plans to streamline the commercialization of NIST-developed technologies. As 2020 has been a year of significant change, the VCAT also explored the evolving strategic context in which NIST operates and the challenges it must be prepared to address over the next several years. The work of the VCAT on these issues is summarized below.

2a. NIST Efforts to Advance Emerging Technologies

NIST directly impacts the competitiveness of U.S. industry through fundamental research breakthroughs in emerging areas like quantum science and artificial intelligence (AI) that accelerate the development and adoption of multiple "bleeding edge" technologies. These technologies transform our economy by delivering both economic and national security advantages to the U.S. Throughout the year the VCAT reviewed NIST plans and received updates on progress and achievements in the strategic focus areas of quantum information science, AI, engineering biology, the internet of things (IoT), as well as advanced communication.

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Quantum Science:

NIST's world-leading expertise in quantum science, conducted with academic and industry partners, is furthering the development of new quantum measurement technologies upon which U.S. companies can build new businesses and services.



Artificial Intelligence:

NIST is developing measurements and data that address the performance and reliability of AI systems to accelerate their widespread adoption and allow the nation to realize the potential economic, societal, and innovation benefits that AI systems offer.



Engineering Biology:

NIST is enabling the design and manufacture of biological systems — for products such as high-value pharmaceuticals and commodity chemicals — by developing advanced measurement capabilities from the molecular to the cellular system scale.



Internet of Things:

NIST is leveraging its expertise in advanced communications, manufacturing systems, cybersecurity, and more to develop testing tools, best practices, and standards that support the widespread deployment of safe and reliable internet of things (IoT) technologies and applications.

Figure 1. Four NIST Strategic Focus Areas highlighted in the President's FY 2021 Budget Request

The VCAT supports NIST's continued focus in these areas that are essential to support broader U.S. efforts to maintain a competitive advantage in high-value sectors. The NIST programs are oriented to ensure that researchers, manufacturers, and other stakeholders have the measurement and standards tools they need to drive discoveries and to facilitate the deployment, adoption, and interoperability of technologies. Over the past year NIST has made several significant accomplishments towards these efforts as described below.

VCAT is pleased to see the continued progress with the Quantum Economic Development Consortium (QED-C). The QED-C has been a tremendous success, bringing together nearly 200 potential members, strengthening ties between NIST and the public and private sectors. The consortium is beginning to provide a coordinated voice for industry to inform and guide R&D (research and development) investment priorities, standards and regulation, as well as workforce education and development. The coordination around voluntary consensus standards was especially important with increased efforts in the International Telecommunication Union and other international standards bodies. NIST will be looking to franchise the QED-C model with global partners in the future.

With a significant concentration of world-leading talent in quantum science, especially in the area of metrology, NIST continues to produce an impressive array of research outputs, paving the way for new quantum tool development. One of the examples is NIST's work in combining several precision measurement capabilities into one tool that can make three different atom-scale measurements simultaneously. Together, these measurements can uncover new insights about a wide range of special materials that are crucial for developing the next generation of quantum computers, communications, and a host of other applications. While these individual investigators' achievements are important and should be encouraged, the VCAT urges NIST to continue to strengthen and expand focused and coordinated outcome-oriented efforts associated with its quantum network grand challenge. NIST has a unique concentration of resources and talent to develop a simplified quantum network as a proof-of-principle. A breakthrough in quantum networking would be a significant contribution to the broader

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national effort by helping the research community to identify and understand potential bottlenecks. An example of NIST's work in this area is the planned effort to demonstrate a compact scalable quantum repeater.

The VCAT was also pleased to see the progress that NIST has made in its efforts focused on AI. A major element of NIST's efforts in AI are aimed at defining and developing the key concepts of trustworthy AI. Over the past year NIST launched a series of workshops to gather input from the AI community about the technical requirements needed to cultivate trust in AI: how to ensure that AI systems are accurate and reliable, safe and secure, explainable, and free from bias. Several important draft documents on these topics were issued by the Information Technology Laboratory during 2020 and the VCAT looks forward to future briefings from NIST on the results of these AI efforts.

NIST has also made significant advances in the application of AI across all its programs where scientists are applying AI and machine learning to a range of technology areas – from collaborative robotics to biometric identification. One AI-focused activity in the Materials Measurement Laboratory is targeting advanced materials discovery under the acronym JARVIS (joint automated repository for integrated simulations). AI work in the Communications Technology Laboratory is focused on 5G and advanced communication through the Synthetic Aperture Measurements of Uncertainty in Angle of Incidence (SAMURAI) system that uses AI to support antenna optimization frequency sharing, a capability needed to meet the capacity demands of interconnected 5G Internet of Things devices. These are some of the prime examples of how the incorporation and application of AI into NIST mission delivery can have a significant impact on technology communities.

In addition to these efforts NIST has also made significant headway against the priorities and plans they have set in the areas of IoT, advanced communications, engineering biology, cybersecurity, and resilience. For example, in the area of cybersecurity, the NIST Security and Privacy Frameworks are foundational in developing cost-effective IT hygiene programs that reduce vulnerabilities and available surface area targeted for attack by bad actors. The frameworks support execution and transparency actions for security governance and emerging privacy considerations. These frameworks are critical tools for those working to protect modern network connected platforms that service consumers, patients, students, employees, and supply chains. An additional example in the area of advanced communications NIST has developed the NIST 5G Spectrum Sharing Test Bed that is enabling testing of the impact of spectrum sharing on communications and RF (radio frequency) remote sensing in adjacent bands. To support the spectrum sharing needs of government, NIST continues to lead the National Advanced Spectrum and Communications Test Network (NASCTN), a multi-agency-chartered partnership that includes Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), the National Telecommunications and Information Administration (NTIA), and academic partners, with the goal to provide validated data and models to guide key spectrum sharing decisions affecting our Federal partners.

NIST has continued to generate an impressive list of outputs and accomplishments, even during this difficult and tumultuous year, but the VCAT is concerned that NIST's programs are stretched too thin. Science and technology continue to evolve rapidly and bring transformational capabilities that cut across the entire economy, including in manufacturing processes, transportation systems, critical infrastructure, and healthcare. For these advances to have a positive impact on the U.S. economy and improve the quality of life requires the ability to address significant measurement and standards

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challenges in areas like interoperability, security, usability, performance, and resiliency. Despite the real need for expanded NIST capabilities, and the increasingly competitive global S&T (Science & Technology) environment in which the U.S. resides, NIST has faced four years of stagnant budgets. The VCAT commends NIST for its efforts to prioritize and focus its investments in the areas most critical to U.S. competitiveness, as well as its efforts to leverage its capabilities and resources and to expand the impact of its research programs by partnering with both the public and private sector. However, without sustained increases in resources it will be extremely difficult for NIST to continue to compete for the necessary staff, support a modern research infrastructure, and build the research depth necessary for sustained impact. The VCAT looks forward to working with the incoming leadership of the Department to shape a proactive approach for NIST to address the S&T priorities of the nation.

2b. NIST Support for U.S. Manufacturers

NIST has a unique role in the U.S. innovation ecosystem with its role and mission to provide support targeted at strengthening manufacturing. NIST has been a strong partner of the manufacturing sector for over 100 years. The NIST portfolio of programs spans fundamental and applied research as well as programs designed to help U.S. industry develop and implement new technology, develop robust supply chains, and refine their systems for efficiency and effectiveness, all while making them more competitive in the global economy.

- The NIST laboratory programs currently (as of FY 2020) invest \$147.9 million annually in support of advanced manufacturing, ranging from work on materials design and discovery to the use of collaborative robots in factories, to biomanufacturing and standards for data exchange and processing manufacturing information. The manufacturing industry uses NIST test methods, measurement tools and know-how, and scientific data, every day. NIST and its scientists also actively participate in industry-led standards activities ASTM (American Society for Testing and Materials), ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), etc.) and consortia. NIST traceable standards can be found in all aspects of manufacturing.
- The Manufacturing USA network is coordinated by the interagency Advanced Manufacturing National Program Office (AMNPO), hosted at NIST and staffed by representatives from federal agencies with manufacturing-related missions (i.e.; NIST, the Departments of Defense, Department of Energy, NASA, and NSF) as well as fellows from manufacturing companies and universities. Manufacturing USA is a network of 16 manufacturing innovation institutes located across the country where companies, universities, community colleges, and entrepreneurs develop new manufacturing technologies with broad applications. The Federal government's commitment of over \$1 billion to the sixteen institutes has been matched by over \$2 billion in non-Federal resources from across industry, academia, and state governments, demonstrating the remarkable catalyzing effect of matching funds. State governments contributed more than \$400 million — underscoring the importance of advanced manufacturing to the future success of state and local economies. Manufacturing USA education and workforce training programs have reached nearly 200,000 individuals and include programs focused on training veterans in advanced manufacturing skills.
- The MEP program is a federal-state-industry partnership that consists of centers located across the country. MEP works directly with their local manufacturing communities to strengthen the competitiveness of our nation's domestic manufacturing base. NIST MEP provides technical assistance in adopting advanced manufacturing technologies, addressing emerging

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manufacturing needs, and understanding foreign manufacturing and compliance issues. The centers provide guidance on cybersecurity of supply chains and transferring technology from NIST labs and other federal research organizations. Since its creation, MEP has worked with 94,033 manufacturers, leading to \$111.3 billion in sales and \$18.8 billion in cost savings, and has helped create and retain 985,317 jobs. As a result of MEP services, in FY 2019 manufacturers reported \$15.7 billion in new and retained sales, \$4.5 billion in new investments, \$1.5 billion in cost savings and 114,650 jobs created or retained in FY 2019. A recent study found that the \$140 million invested in MEP by the federal government had a nearly 13.4:1 return on investment.

In 2020 the VCAT was pleased to see NIST bring on Ms. Mojdeh Bahar as the Associate Director to lead the NIST Innovation and Industry Services (ADIIS) Programs. The VCAT is highly supportive of her efforts to strengthen the synergies between the programs in her directorate (MEP, Manufacturing USA, Baldrige Performance Excellence Program, and the Technology Partnerships Office). These programs help NIST build communities around technological innovations, manufacturing, and performance excellence through key public-private partnerships. The VCAT looks forward to reviewing progress in future years on how these efforts have helped programs to collectively expand their reach, identify new external partners, and improve the dissemination of these NIST program impacts.

The VCAT was pleased to see the changes in the legislation for the Manufacturing USA Program that were passed as part of the 2019 National Defense Authorization Act. Specifically, the legislation:

- Provides NIST the ability to renew federal funding for any manufacturing institute meeting performance standards;
- Emphasizes the importance of education and workforce development;
- Provides authority for pilot programs and public service grants in support of any institute;
- Encourages the establishment of new advanced manufacturing institutes; and
- Creates a new mechanism facilitating private companies or nonprofits to join the Manufacturing USA network.

These changes to authority, when matched with appropriations, will give the Manufacturing USA program the necessary flexibility to strengthen the environment for U.S. manufacturing.

The VCAT was also encouraged to see what steps MEP was taking to strengthen its connectivity to the other ADIIS programs and the NIST Labs. MEP's efforts to expand collaboration with the Manufacturing USA institutes are focused on the programs targeting manufacturing 4.0. NIST MEP is providing funding of up to \$1 million to various MEP Centers to implement build capabilities to deliver new services to manufacturers. For example, Florida MEP (FloridaMakes) will develop and implement a new, manufacturing-specific assessment tool incorporating *Industry 4.0* principles within the Baldrige framework. Through these assessments, used as standalones or through regional, state, and/or national award processes, companies will be able to benchmark themselves against the criteria, and/or against each other, and understand pathways to improve their competitiveness and technological performance. To deepen the connection between MEP and the NIST laboratories, MEP launched the MEP-Assisted Technology and Technical Resource program designed to facilitate MEP client access to expertise and technical resources in the NIST laboratories. The effort is in its early stages; over 50 engagements occurred over the past year.

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The pandemic exposed the fragility of U.S. manufacturing with significant disturbances to operations, disruptions in supply chains for critical components, and increased costs of production. Programs at NIST, like MEP and Manufacturing USA will be critical in supporting a robust U.S. recovery. In turn, the research efforts in the labs will help in the rapid development and deployment of technological solutions, such as exposure notification tracking applications, that can help mitigate the impact of future pandemics. The VCAT looks forward to working closely with the NIST leadership and the Biden Administration to realize the full potential of NIST to support advanced manufacturing and further U.S. economic recovery.

2c. NIST Efforts to Enhance Technology Transfer

The VCAT has been closely engaged with NIST efforts to strengthen and streamline the transfer and commercialization of technology, developed as a result of Federal R&D, since NIST launched its ROI initiative in 2018. NIST has made significant strides in advancing this effort over the past 2 years. NIST provided the results of this nationwide effort in 15 key findings in a final version of the NIST [“green paper”](#) on maximizing U.S. innovation from government-funded research. This effort directly supported the President’s Management Agenda and its Lab-to-Market Cross Agency Priority goal. The green paper findings led to community-informed legislative and regulatory proposals to modernize the Stevenson-Wydler Technology Innovation Act of 1980 and a proposed regulatory update of the Bayh-Dole Act. The VCAT was pleased to see that the [“Return on Investment Initiative” Legislative Package](#) was delivered to Congress in late 2020, and that a Notice of Proposed Rule Making for the Bayh-Dole Act has been published in the [Federal Register](#) with a comment period open through April 2021. The VCAT looks forward to providing whatever additional support is necessary to help see this initiative to fruition.

The VCAT was also briefed on additional efforts that NIST has implemented in its own laboratories to improve the transfer of NIST-developed technologies. Chief among these efforts was the Technology Maturation Accelerator Program (TMAP). In 2020 NIST launched the second round of TMAP to fund proposals from the NIST Laboratories to accelerate the maturation of emerging technologies with significant commercial promise. The program funds projects that improve the Technology Readiness Level (TRL) of early stage technologies, for which feasibility has been demonstrated in the laboratory, towards a higher TRL prototype. NIST also actively engages its lab scientists in creating awareness of commercialization opportunities and holds virtual sessions such as “Tech Transfer 101 Training: A Scientist’s Perspective on Tech Transfer.”

2d. Evolving Strategic Context and Emerging Challenges

With 2020 being a year of significant transition, both due to the pandemic and presidential election, in October the VCAT explored in depth some of the trends and issues that NIST should be prepared to confront in the coming years.

The VCAT heard from Dr. Robert Atkinson, President of the Information and Technology Innovation Foundation, on his views of the state of the U.S. high-technology sector, his opinion on what needed to be done to address existing weaknesses, and potential roles for NIST. Dr. Atkinson reviewed several economic measures painting a troubling picture for the long-term competitive posture of the U.S. Dr. Atkinson provided his views on how best to address these shortcomings advocating for a more hands-on manufacturing and technology policy from the U.S. Government. This would include combining increased investment in R&D, coupled with increases to programs like MEP and Manufacturing USA, as

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well as the return of focused technology development programs as central pillars. Dr. Atkinson also highlighted the challenges raised by China including the new China Standards 2035 strategy, which will require increased capacity at NIST.

The VCAT also reviewed an updated Environmental Scan prepared by the NIST Program Coordination Office. The 2020 *National Institute of Standards and Technology Environmental Scan* provides an analysis of key external factors that could impact NIST and the fulfillment of its mission in the coming years. The analyses were conducted through four separate lenses: Societal, Investment & Geopolitical, Political & Policy, and Technology & Science. Informed by the 2018 Environmental Scan also prepared by NIST, many of the issues discussed then are still relevant, but several additional key issues have emerged that will impact NIST since the writing of that report. Most notably, recent issues emerged related to the COVID-19 pandemic and the national discourse around race. Societal inequality, political division, mistrust of institutions, financial constraints, and workforce issues will challenge NIST to maintain and advance its leadership in metrology, standards, and technology. However, a broad range of emerging technology issues present opportunities for NIST to significantly impact advances in the nation's innovation and industrial competitiveness. The VCAT found the analysis to be very insightful and encourages NIST to continue this best practice on a regular basis.

The VCAT believes that the priorities and actions defined in the NIST Strategic Plan (discussed in more detail in section 4 of this report), especially those focused on strengthening the NIST workforce and addressing issues around diversity and equity, put NIST on a good path to addressing many of the societal challenges identified in the environmental scan.

The VCAT also agrees with NIST leadership that many of the priorities outlined by Dr. Copan including: strengthening U.S. standards engagement; continued focus on advanced communications; leading U.S. efforts on strengthening advanced manufacturing in the U.S.; cultivating an inclusive workforce; cybersecurity and privacy; and NIST's ongoing efforts to advance emerging technologies, should remain a focus of NIST moving to the future. Additionally, with the transition to the Biden Administration it is likely that NIST will also face calls to support efforts to address climate change and promote alternative energy technology development through measurements and standards.

RECOMMENDATIONS:

1. Support economic recovery from the COVID-19 pandemic by providing focused resources through MEP and Manufacturing USA for:
 - a. Continuing to enable companies to transform their operations to support COVID-19 related needs and increase resilience in pandemic-impacted supply chains.
 - b. Fund additional high-impact biopharmaceutical manufacturing projects to support the nation's response to the pandemic.
2. Ensure that the NIST workforce and partner organizations supporting standards development and negotiation have all necessary tools and resources to represent the nation fully and vigorously while working under pandemic-driven travel and workplace constraints.
3. Augment NIST activities in trustworthy AI to include developing a framework or standards for verification, validation and accreditation of AI systems, in order to accelerate adoption and acceptance of these systems in support of the nation's economic competitiveness and national security.

3. NIST Efforts to Respond to COVID-19

The coronavirus pandemic has changed daily life globally for the majority of 2020 and beyond. As of the end of October 2020, there are almost 45 million confirmed cases of COVID-19 and over 1.1 million deaths globally, according to data provided by Johns Hopkins University. Out of a necessity to protect employee health and safety, both NIST campuses in Gaithersburg and Boulder closed with limited access from mid-March to mid-July. Most of NIST staff are still on maximum flexibility telework indefinitely, with about 20% of critical mission staff and researchers returning to campus as of October. Transitioning to an all-virtual workplace was not an easy task, but the Information Technology (IT) staff helped make a successful transition to telework and researchers shifted to remote work, paper writing, or applying their research techniques to COVID-related projects. NIST added training and seminars to help with learning and navigating new virtual platforms as staff continued to carry on the NIST mission. NIST is closely monitoring the local case load around its campuses and has developed a thorough mitigation plan and training for all staff returning to campus. As the pandemic has not been contained and a vaccine is not yet available to NIST staff broadly, the full long-term impact is yet to be seen.

The VCAT commends NIST for the data-driven and science-based approaches that it has implemented to protect the health and safety of its workforce. NIST's ability to transition 6,000+ federal employees and associates to mandatory telework, which included getting agreements in place, powering down equipment, providing the necessary IT tools and equipment, and figuring out how to make bench research remote, was an impressive feat that was executed with minimal disruption. In fact, the transition to telework is one of the few bright spots of the pandemic, as it has clearly demonstrated the value and potential of telework and remote work to NIST. The majority of staff have been able to fully perform their duties from a telework posture and many look forward to and expect an increased use of telework even after the pandemic has subsided. Increased use of telework in the future creates new opportunities for NIST with respect to space utilization, and the recruitment and retention of staff.

As of the date of this report, NIST still does not know the full impact of the pandemic. The institute's financial future remains to be seen. Solvency is a concern due to loss of on-site conference hosting, a projected increase in administrative leave and decrease in annual leave, and increased IT costs. Additionally, measurement sales are impacted since SRMs/RMs (Standard Reference Materials) and calibration services are delayed or not all available, and state and local governments have fewer funds to spend on these services and products. Research projects can also be delayed, which could impact future partnerships or standards development. Many staff are also now juggling caregiving needs with telework and there is an increased number of retirements occurring that could have an impact on NIST's skill, retention and depth in key mission delivery areas. The VCAT looks forward to hearing future updates from NIST on the longer-term impacts of the pandemic and on NIST's planned mitigation efforts.

Despite these challenges NIST programs, and in particular the NIST staff, have readily stepped forward to contribute their time, talents, and expertise to help combat the pandemic. The breadth of NIST's

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programs has enabled a diversity of [projects](#) to aid the national and worldwide coronavirus pandemic response. It has truly been an inspiring response.

In addition to these grass roots efforts NIST received an additional \$66 million in CARES (Coronavirus Aid, Relief, and Economic Security) Act funding across the Innovation and Industry Services (\$60 million) and Laboratory (\$6 million) programs. In late March, NIST launched an internal [crowdsourcing effort](#) to identify additional laboratory project opportunities and bring staff together to address multidisciplinary research challenges. NIST continues to expand its international and domestic partnerships to address measurement challenges related to the pandemic. Updates are regularly posted to the NIST website: <https://www.nist.gov/coronavirus>.

In brief, NIST responses to COVID-19 include:

- Leveraging National Networks: NIST awarded funds to all 51 MEP centers to support manufacturers across the country to transform their operations to support COVID-19 related needs and aid in development of pandemic-related supply chains. NIST awarded funds to Manufacturing USA institutes for high-impact biopharmaceutical manufacturing projects to support the nation's response to the pandemic.
- Biological Measurements: NIST is applying expertise in applied genetics, biomolecule characterization, high-throughput testing, and statistics to advance reliable SARS-CoV-2 detection tests and antibody assays working with other organizations in the U.S. and worldwide.
- Personal Protective Equipment (PPE): NIST research outputs include characterization of different PPE decontamination methods from UV light to vapor treatments, and aerosol measurements and air flow visualizations to assess the performance of fabrics used in face coverings. NIST helped industry and other federal agencies access technical standards for production and testing of PPE and is currently supporting an ASTM International effort to develop voluntary standards for consumer face coverings.
- Technology Solutions for Safer Communities: NIST is using long-standing data and technology capabilities in areas like information search, privacy and cybersecurity, machine learning, and wireless signals to develop measurement tools to understand whether and how technologies like exposure notification and indoor airflow models can blunt the spread of pandemics.

RECOMMENDATIONS:

- New emerging COVID-19 variants displaying varying transmissibility, severity, and vaccine immunity responses are likely to require new characterization, testing and monitoring techniques. VCAT recommends that NIST utilizes expertise in biological measurements, applied genetics, biomolecule characterization, high-throughput testing, and statistics to advance reliable and discriminating tests, antibody assays, and analytic techniques working with other organizations in the U.S. and worldwide.
- Create a priority project to devise tools, techniques or approaches (including "NIST on a chip" applications) to improve efficiency and cost effectiveness of calibration and measurement services in the pandemic environment with anticipated long-term impacts to workplaces, workforces, and state and local budgets.

4. NIST Strategic Planning

The VCAT continued to receive ongoing updates on NIST's strategic planning efforts and their progress in implementation over the course of FY 2020. Throughout the year NIST has been working to implement eight Actions that were identified as priorities for implementation based on input from the NIST Leadership Board and the NIST community. As discussed previously these actions are listed in the following figure:

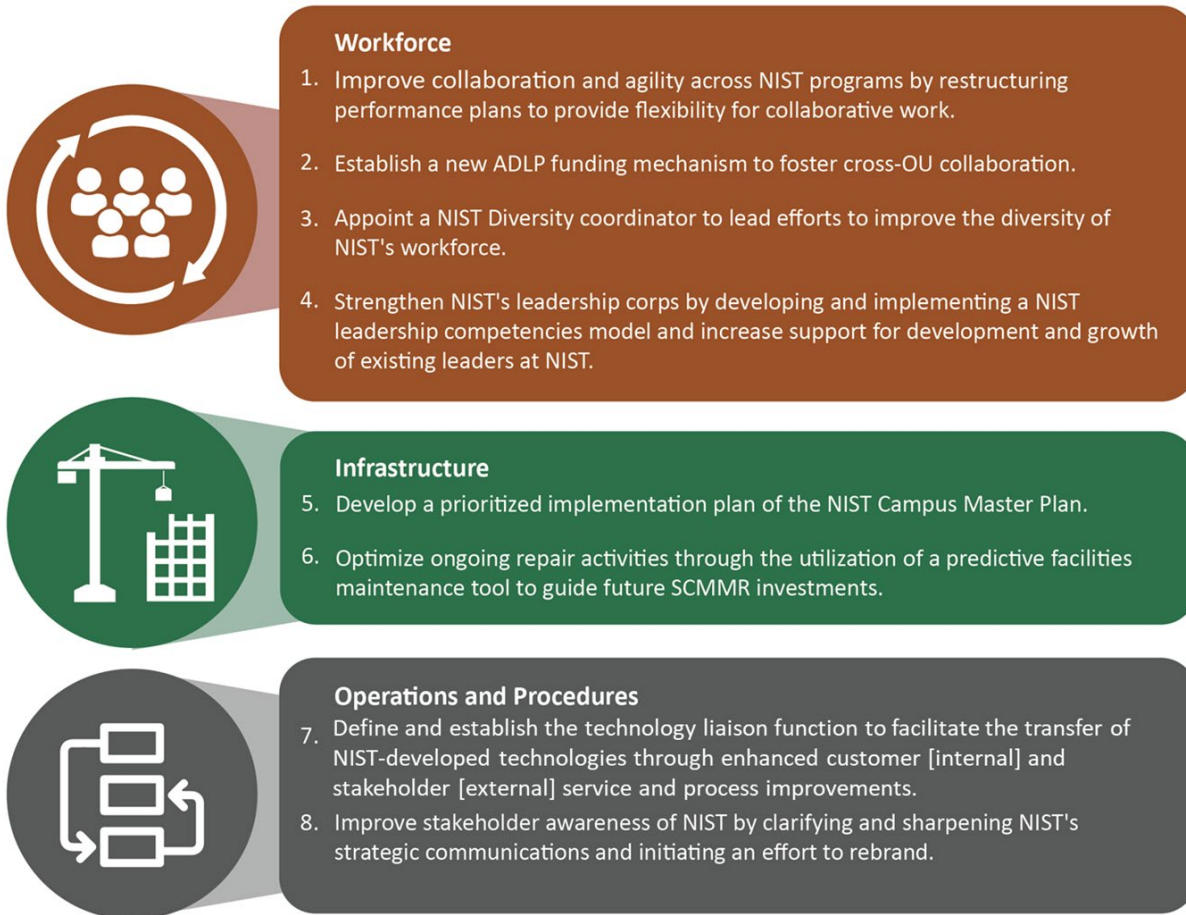


Figure 2. Graphic outlining 8 Actions for the NIST Strategic Plan, presented to VCAT at the June 2020 meeting.

NIST has established an evaluation cycle where progress on each Action is evaluated at six-month intervals, at which time progress will be reviewed and additional actions, outlined in the master plan, will be prioritized and identified for the next round of implementation. This process ensures that NIST is systematically implementing the proposed Actions and making consistent and steady progress toward its ultimate aim of ensuring that NIST continues to be an essential and valued component of America's innovation ecosystem.

The VCAT continued to pay particular attention to two of these initiatives the Committee feels are important for NIST to address and make sustained progress on: NIST's efforts to strengthen diversity,

equity, and inclusion at NIST; and, NIST efforts to improve stakeholder awareness by clarifying and sharpening NIST's strategic communication and brand.

As the VCAT has noted before, a diverse and inclusive workplace is necessary for attracting and retaining an innovative and highly skilled scientific and technical workforce. Research shows that diverse workplaces lead to increased creativity, innovation, and organizational performance, and inclusive and equitable workplace cultures improve employee engagement and retention. The VCAT supports NIST's efforts to take a strategic and long-term approach to building a diverse workforce along with improving the workplace culture in parallel. The VCAT was briefed on a number of initiatives that are underway, including examining promotion and pay-setting practices, developing and adopting best practices for hiring new employees, expanding training on bias and allyship, launching a mentoring program, offering training and leadership opportunities, and ensuring support for staff including the establishment an Organizational Ombuds. The VCAT was pleased to see the progress NIST has made in terms of establishing the position and process to recruit and hire a Director of Diversity and Inclusion who will help unify efforts across NIST and provide continued focus and energy around these important issues. The VCAT realizes that changing the culture at NIST is a difficult process that must be persistently worked at over a long period. As such the VCAT believes that it is important for NIST to develop good measures to track progress in creating a more diverse and inclusive workplace to maintain focus on these efforts and ensure the organization benefits from the ongoing actions.

As NIST leadership and the VCAT have discussed, NIST does not have a consistent, recognizable brand that clearly communicates NIST's priorities, capabilities, and value. As part of the effort to address this issue NIST, through its Public Affairs Office, has awarded a contract to conduct a branding study. The NIST branding study is aimed at improving stakeholder awareness of NIST by clarifying and sharpening NIST's strategic communications. The study is in its early stages, with a team collecting input from NIST leadership and staff, as well as external stakeholders -- including members of the NIST VCAT. The VCAT looks forward to the results of this study and the proposed next steps. It is also the opinion of the VCAT that a well-articulated brand will not be enough so long as a large portion of NIST communications happens outside of the Public Affairs Office. Uncoordinated messaging, including competing outreach among internal NIST organizations, hurts a unified NIST brand. To achieve measurable strategic communications goals, NIST needs discipline and consistency in messaging.

RECOMMENDATIONS:

- Create branding packages, guidelines, and toolkits for all NIST organizational elements and employees to achieve uniformity and consistency in branding and messaging both internally and externally.

5. NIST Facilities and Infrastructure

The VCAT has been tracking the status of NIST facilities and infrastructure for the past several years, and remains concerned that each year, NIST's ability to maintain and renovate its infrastructure has been falling further and further behind. NIST's ability to maintain and modernize its facilities has been stymied by several factors including inefficient Federal procurement processes and an unstable and unpredictable funding stream. The insufficient resources in NIST's general maintenance fund have necessitated unacceptable and impossible choices between temporary fixes in NIST's general laboratory

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spaces, administrative buildings, and plant facilities instead of implementing a more strategic approach to improving the condition of NIST's campuses that was presented to the VCAT this year.

In FY 2020 NIST submitted its Implementation Plan for integrating the master plans for the 2 campuses to Congress. This plan identifies the top 10 large capital projects in rank order, with estimates and projected schedules for completion depending on funding availability. Having a long-range plan for these significant projects will allow NIST to properly plan and execute its capital construction program.

The top five projects identified for Gaithersburg are:

1. New Research Building 228;
2. Building 101 Renovation;
3. Building 221 Renovation;
4. Gate F Shipping and Receiving Facilities for Security; and
5. Building 220 Renovation.

The top five projects for Boulder are:

1. Building 1 Renovation, Wing 5;
2. Building 2 Replacement;
3. Building 3 Addition;
4. Renovate Building 24; and
5. New Childcare Center.

To develop a path forward NIST has been working with Congressional appropriators to establish a sustainable level of base funding for both meeting the needs of capital construction, as outlined in the master plan, as well as providing the ability for NIST to make significant headway in addressing its deferred maintenance backlog. This backlog was well over \$700 million when the VCAT was briefed earlier in the year. NIST is proposing an annual investment of between \$60 and 80 million for capital construction, to provide the flexibility and stability necessary to implement the NIST campus master plan. For ongoing maintenance needs and to address the backlog, federal and industry guidelines indicate that NIST would require between \$115 to \$144 million annually to maintain its facilities. Based on trends of the last 4 years, NIST is trying to establish an annual maintenance and repair funding level of \$100 million. The VCAT has been briefed that this is a funding level that NIST can execute based on recent and ongoing improvements to staffing, procedures and proactive planning efforts.

The VCAT fully supports NIST's goal of establishing a base level of funding of \$160 to \$180 million a year to address its construction and renovation needs and will work to continue to point a spotlight on this issue which if left unaddressed will completely degrade the ability of NIST to support the research and development highlighted earlier in this report.

RECOMMENDATIONS:

- Continue working with OMB and Congressional appropriators to establish and sustain the annual level of investment required for the nation's critical infrastructure entrusted to NIST for advancement of standards, advanced technology, and manufacturing excellence.

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- Invest in the information technology (IT), business process and digital transformation capabilities needed for NIST to sustain world leadership in standards and technology in today’s virtual and collaborative work environment.
- Provide NIST with increased flexibility in the use of its CRF resources with authorities to create capital investment resources through monetization of NIST properties and facilities; move activities to lower cost venues; and remove restrictions on modification or demolition of designated historic structures.

6. NIST Budget (FY 2021 Enacted)

FY 2021 Enacted Budget

FY 2020 Enacted NIST Budget (Dollars in Millions)

	FY 2020 Enacted	FY 2020 CARES Act P.L. 116-136	FY 2021 Request	FY 2021 House Mark	FY 2021 Senate Mark	FY 2021 Enacted	+/- over FY 2020 Enacted
STRS	\$754.0	\$6.0	\$652.0	\$789.0	\$786.5	\$788.0	\$34.0
Laboratory Programs	655.8	TBD	591.3	TBD	TBD	TBD	TBD
Corporate Services	17.3	0.0	12.0	TBD	TBD	TBD	TBD
Stds Coord & Special Pgms	80.9 *	TBD	48.7	TBD	TBD	TBD	TBD
ITS	\$162.0	\$60.0	\$25.3	\$170.0	\$165.5	\$166.5	\$4.5
Hollings Mfg Ext Partnership	146.0	50.0	0.0	153.0	149.5	150.0	4.0
Manufacturing USA	16.0	10.0	25.3	17.0	16.0	16.5	0.5
CRF	\$118.0	\$0.0	\$60.2	\$85.0	\$98.0	\$80.0	(\$38.0)
Construc & Major Renovations	43.0	0.0	19.6	10.0	8.0	TBD	TBD
Saf, Cap, Maint & Maj Repairs	75.0	0.0	40.6	75.0	90.0	TBD	TBD
Total, NIST Discretionary	1,034.0	66.0	737.5	1,044.0	1,050.0	1,034.5	0.5

*Includes \$2.2M Baldrige Performance Excellence Program funding.

The VCAT was briefed on the FY 2021 budget and appropriations cycle. The resolution of the FY 2021 budget cycle happened at the very end of the year. While the VCAT was pleased to see that the drastic cuts proposed in the President’s budget were not enacted, the overall budget remains flat when compared with topline funding from FY 2020. The VCAT was pleased to see that the proposed elimination of MEP was rejected, and that there were some, albeit incremental, increases to NIST research efforts focused on quantum science and artificial intelligence. However, to remain internationally competitive, to fulfill the increased demands to advance emerging technology areas, and to strengthen U.S. manufacturing requires a significant investment above current levels. Perhaps most disappointing was the \$38 million decrease NIST incurred in its construction budget. This decrease will only serve to further the decline of NIST’s facilities, delay progress on ongoing projects, increase the already astronomical deferred maintenance costs, and increase the likelihood of further catastrophic infrastructure failure that has the potential to shut down large portions of the NIST facilities for prolonged periods of time.