2022 Annual Report

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

U.S. Department of Commerce

March 2023

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 2022 annual report covers the period from March 2022 through February 2023.

The VCAT reviews and makes recommendations regarding general policy for the National Institute of Standards and Technology, its organization, its budget, and its programs, within the framework of applicable national policies as set forth by the President and the Congress, and submits an annual report to the Secretary of Commerce for submission to the Congress. 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.

The Committee reviews a significant portion of NIST programs through direct discussion with NIST leaders, scientists, and engineers. Committee members present candid feedback to NIST senior management and other attendees at each meeting and encourage continuous dialogue. This feedback encourages continuous improvement in key areas in the overall operation of the Institute. The Committee normally visits various NIST laboratories and satellite facilities to discuss research projects directly with NIST 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 how effectively the existing facility infrastructure meets the needs of the NIST mission. During this period of performance, meetings were both in-person and virtual.

Under the Committee charter, the Director of NIST appoints the VCAT members. Members are selected on a transparent, standardized basis, in accordance with applicable Department of Commerce (DOC) 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 consulting, environment, and international relations; and shall be selected in accordance with applicable DOC guidance. 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, two VCAT members completed their two consecutive three-year terms: Dr. Gail Folena-Wasserman (AstraZeneca/MedImmune) and Mr. David Vasko (Rockwell Automation). During this reporting period, one new VCAT member, Mr. Jason Matusow (Corporate Standards Group at Microsoft Corporation) was appointed.

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

VCAT Members during the Period Covered by this Report

Dr. Mehmood Khan, Chair
Hevolution Foundation
Term: November 13, 2018 – November 12, 2024

Dr. Dana (Keoki) Jackson, Vice Chair
MITRE Corporation
Term: May 22, 2018 – May 21, 2024

Dr. Vinton G. Cerf
Google
Term: December 21, 2018 – December 20, 2024

Mr. George Fischer
T-Mobile
Term: May 22, 2018 – May 21, 2024

Dr. Anthony M. Johnson
University of Maryland Baltimore County (UMBC)
Term: October 4, 2021 – October 3, 2024

Dr. Eric Kaler
Case Western Reserve University
Term: December 21, 2018 – December 20, 2024

Ms. Katharine Ku
Wilson Sonsini Goodrich and Rosati
Term: May 22, 2018 - May 21, 2024

Mr. Jason Matusow
Microsoft
Term: September 14, 2022 – September 13, 2025

Dr. Michelle Parker
Boeing
Term: January 14, 2022 – January 13, 2025

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

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

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Executive Summary

Over the past year, NIST has continued to demonstrate that it is a world-class, one-of-a-kind asset for the Nation. The institute continues to make impressive progress on measurement science, standards, and technology.

Dr. Laurie Locascio was sworn in as the 17th NIST Director on April 7, 2022. A longtime NIST scientist, she has experience conducting research and serving in leadership roles at the Institute, including as the acting NIST Associate Director for Laboratory Programs. Most recently, Dr. Locascio served as the Vice President of Research at the University of Maryland College Park and University of Maryland Baltimore. In our June meeting, Dr. Locascio emphasized her vision for NIST to support America's competitiveness in the global economy. The VCAT fully supports her emphasis on five key themes:

1. Bolstering NIST's essential role in the development, manufacture, and adoption of critical and emerging technologies.
2. Ensuring U.S. leadership in international standards.
3. Manufacturing leadership executed by NIST programs including CHIPS, the MEP, Manufacturing USA, and the research efforts of the NIST laboratories.
4. Ensuring NIST is fully resourced to deliver on its mission, including its facilities.
5. Building a community where everyone is safe, valued, supported, engaged, and empowered.

The passage in August 2022 of the CHIPS and Science Act ushered in a new era at NIST. Implementing the CHIPS and Science Act is an unprecedented task for NIST that brings great opportunity to develop partnerships with the semiconductor industry, develop innovative measurements and technologies in support of the semiconductor industry, and support the U.S. manufacturing and supply chain landscape. However, it also creates great challenges that include balancing the immense efforts of the CHIPS Office with maintaining the health of other NIST mission priorities while quickly growing the NIST workforce.

The VCAT is pleased that NIST has been trusted to implement the CHIPS and Science Act, but also cautions that it is important to maintain the health of all other mission-critical activities at NIST. The VCAT likes the growth in the FY 2023 budget but is concerned about the increases related to CHIPS Act-directed appropriations and external earmarks. Implementing the earmarks increases the administrative workload without additional funding and can distract staff from implementing the core NIST mission. Ideally, should the earmarks continue, more resources (budget and staff) would be provided for dealing with the earmark administrative workload. However, the VCAT is most concerned about providing robust funding for intramural NIST labs and special programs in FY 2024 and beyond so that the Institute can continue to achieve its core mission for the Nation.

The VCAT believes that the following issues deserve immediate attention:

- Significant new investment in the NIST facilities is absolutely required for NIST to meet its critical mission to support U.S. industry and innovation. This issue has been repeatedly noted by VCAT in past reports. VCAT supports the findings and recommendations of the recent assessment of NIST facilities undertaken by the National Academies of Science, Engineering, and Medicine. The

Academies report found that NIST is already suffering productivity losses of between 10 % and 40 % due to rework, repairs, and workaround efforts by the researchers.

- NIST must be adequately resourced to meet the growing list of responsibilities that they are called upon to address—from CHIPS-related metrology, supply chain security, to advancing quantum science and trustworthy AI, to strengthening U.S. leadership in international standards and conducting post-disaster investigations that result in improved building codes.
- VCAT notes that if the Institute is not receiving adequate funding to meet the needs for facilities and to implement directed programs, NIST and the Department of Commerce must be prepared to halt key services and programs. The current mode of expecting staff to push through and do more with less is not sustainable.
- The Director's emphasis on community building is essential for NIST, and her efforts to reinforce a safety culture throughout the organization come at a time when the organization is facing extreme challenges as they continue to emerge from the COVID-19 campus restrictions.

The VCAT has high expectations of NIST delivering strong results in high-priority areas such as those outlined in the CHIPS and Science Act, manufacturing, and in Critical and Emerging Technologies (CETs).

The Committee encourages NIST to continue its robust engagement with other bureaus in the Department, including the Bureau of Industry and Security, the International Trade Administration, and the National Telecommunications and Information Administration, to ensure essential connectivity of those entities with foundational NIST work.

Finally, we note with sadness that on September 26, 2022, an engineering technician in the NIST Engineering Laboratory's National Fire Research Laboratory died in a tragic accident while deconstructing an experimental test structure. The VCAT extends its deepest condolences to the family of the late colleague and to the entire NIST community.

1. VCAT Focus in 2022

In 2022, the VCAT focused their efforts on the following priority themes to ensure NIST is fully supporting America's competitiveness in the global economy:

1. Bolstering NIST's essential role in the development, manufacture, and adoption of critical and emerging technologies.
2. Ensuring U.S. leadership in international standards.
3. Executing leadership in Manufacturing by NIST programs including CHIPS, the MEP, Manufacturing USA, and the research efforts of the NIST laboratories.
4. Ensuring NIST is fully resourced to deliver on its mission, including its scientific research facilities such as the NIST Center for Neutron Research (NCNR).
5. Building a community where everyone is safe, valued, supported, engaged, and empowered.

In support of priorities 3, 4, and 5, Dr. Locascio established three VCAT subcommittees (priorities 1 and 2 are being addressed with internal efforts):

Alignment of Manufacturing Efforts, *Chaired by Mr. David Vasko*. This subcommittee was charged with examining the alignment of NIST laboratory outputs, the Manufacturing Extension Partnership (MEP), and the Manufacturing USA program. Some areas of exploration included strategic use of the CHIPS and Science Act to establish alignment, benchmarking against Germany's Fraunhofer and other similar organizations for best practices, as well as development of a matching concierge service to make connections between the NIST laboratories, Manufacturing USA, and MEP.

Visibility Improvement, *Chaired by Dr. Vinton Cerf*. This subcommittee was charged with examining the advancement of NIST's mission, as well as the improvement of visibility and awareness of NIST, including development of clear messaging to communicate NIST's value most effectively across stakeholder groups, mechanisms for the strategic delivery of NIST's messaging, and approaches for increasing the exposure of key stakeholders to NIST's critical work driving American innovation.

Workforce Development Efforts*, Chaired by Dr. Gail Folena-Wasserman*. This subcommittee was charged with examining internal efforts to strengthen diversity, equity, inclusivity, and accessibility (DEIA) among the NIST workforce, as well as NIST's role in external-facing workforce development programs. This included, for example, academic programs for pipeline development, expansion of Manufacturing USA Institute training efforts, and pilot programs to help women return to the workforce after a prolonged absence.

Table 1. NIST VCAT Meetings and Topics Covered in this Report

June 14, 2022 (hybrid)	October 25, 2022 (virtual)	February 8-9, 2023 (hybrid)
NIST Director's Update	NIST Director's Update	NIST Director's Update
Safety Update	Safety Update	Safety Update
Budget Update	Budget Update	Budget Update
Re-entry to Campus	Safety Incident	NIST Safety Commission
NCNR	CHIPS and Science Act	NASEM Assessment of NIST Facilities
Surfside Investigation	Subcommittee Readouts	CHIPS Program Update
NIST Director's Priorities		Community Building
Subcommittees Established		Subcommittee Recommendations

Additionally, the VCAT was briefed throughout the year on NIST's budget outlook and the condition of facilities and infrastructure. The VCAT received detailed programmatic briefings in all these areas. This report summarizes the VCAT's work, observations, and recommendations related to these topics.

2. NIST: Supporting America's Competitiveness in the Global Economy

To succeed in its role as the Federal leader, entrusted with ensuring U.S. leadership in international standards for critical and emerging technologies, NIST must continue to make significant discoveries and technical progress in the underpinning research and development in these areas. Similarly, if the capital facility needs of the Institute are not addressed, NIST will not be able to successfully fulfill its mission in leading measurement, calibration, and standards. Without world-class facilities, NIST will not be able to attract and retain the top talent needed to accomplish these technical advances. The Academies supports the need for annual construction and major renovations (CMR) investments of $300-$400 million (2022 dollars) over 12 years for a total CMR investment of $5.125 billion (2022 dollars). Meeting NIST's DEIA and community-building goals is also key to attracting and sustaining a productive workforce during this time of growth for NIST. The growth is largely driven by the CHIPS and Science Act work, the success of which is now key to achieving NIST's priority of U.S. manufacturing leadership. The interconnection of all themes demands a holistic and robust response across all the key issues prioritized by the NIST Director. The VCAT finds that the priorities defined by the NIST Director are aligned with these requirements for success. Moreover, these priority themes cannot be achieved in isolation, as success relies on fulfilling all noted priorities. This report presents our recommendations to NIST to achieve these goals.

3. Bolstering NIST's Essential Role in the Development, Manufacture, and Adoption of Critical and Emerging Technologies

Throughout the past year, VCAT was briefed by NIST on several significant contributions that the NIST laboratories made in the advancement of critical and emerging technologies. These are important accomplishments for the Nation and VCAT notes that NIST plays a unique role in America's economic competitiveness. Noteworthy examples include the following:

3.1. Health and Biological Systems Measurements

NIST's rapid development of a research grade test material (RGTM) for Mpox (monkeypox) in 30 days deserves acknowledgement for speed and utility. Using technologies stemming from fundamental measurement research at NIST, staff scientists were able to rapidly respond to the national need for a positive control material to ensure quality control of Mpox testing kits. With this material, accurate and rapid testing could be conducted, allowing health professionals to isolate the disease and help slow the spread of a dangerous virus.

3.2. Cybersecurity and Privacy

NIST has made continuous progress on how stakeholders should quantitatively assess security levels of software-based systems while delivering needed guidelines for information technology and cybersecurity. For example:

- NIST released a draft of Revision 4 of NIST Special Publication 800-63, Digital Identity Guidelines for public comment in December 2022. Last updated in 2017, the new guidance is intended to help government systems with risk-management for digital identity while also supporting privacy, equity, and accessibility.
- Additionally, in July 2022, NIST selected four encryption algorithms to be part of NIST's post-quantum encryption standard. NIST aims to finalize the post-quantum cryptography standard in two years, and when produced, will be used to protect digital systems from attacks from quantum computers in the future.
- NIST has continued its efforts towards revising the Cybersecurity Framework (CSF). Originally produced in 2014, the CSF is intended to help organizations manage cybersecurity risk in the changing technology landscape. NIST has taken several steps to develop "CSF 2.0", including hosting a workshop in August 2022 with attendance from over 3,900 attendees from 100 counties. NIST also released a concept paper for public comment that outlines the potential major changes in the new Framework in January 2023. These community engagement efforts will result in the final CSF 2.0, anticipated in winter 2024.

3.3. Critical and Emerging Technologies

NIST has worked extensively to maintain U.S. leadership and ensure both economic and national security in advanced communications technologies and systems and is playing a lead role in the measurement and standardization in this area. For example, in August 2022, the Communications Technology Laboratory (CTL) deployed and commissioned the Open Radio Access Network (O-RAN) for 5G Spectrum Sharing Test Bed on the Public Safety Communications Research Demonstration Network. This new system presents new testing and validation opportunities for equipment vendors. And in November 2022, NIST joined the O-RAN Alliance, a nonprofit organization made up of mobile network operators, vendors, and academic and government institutions working to make radio access network technologies more open, intelligent, and interoperable. By joining the O-RAN Alliance, NIST will enhance U.S. leadership in wireless technologies and promote stable and diverse supply chains, which are a priority for the administration. Additionally, NIST's National Cybersecurity Center of Excellence (NCCoE) is collaborating with 11 technology partners/collaborators through a Cooperative Research and Development Agreement to create practical solutions for addressing 5G security.

In January 2023, NIST released the AI Risk Management Framework (RMF) 1.0. The document was drafted after extensive community engagement, including representatives from industry and entities worldwide. In the coming year, NIST will be working to ensure that the framework drives responsible AI practices by helping those who use AI systems to increase the trustworthiness of these systems while mitigating risks. In addition to the AI RMF, NIST's technical work on bias in AI and biometrics technologies, such as facial recognition, is foundational to the successful implementation of trustworthy AI systems.

NIST researchers continue to advance both the technologies and the fundamental science needed for quantum applications. NIST recently demonstrated a new device on a single microchip that integrated a quantum emitter single-photon source and a low-loss photonic circuit. This is an important step towards chip-integrated photonic quantum information systems. NIST continues to support the quantum ecosystem through engagement with the quantum community through the Quantum Economic Development Consortium (QED-C) and the Quantum Systems through Entangled Science and Engineering (Q-SEnSE) Institute. NIST staff also continue to contribute to the U.S. quantum strategy – a NIST and JILA fellow was appointed as a member of the National Quantum Initiative Advisory Committee to counsel the administration on ways to ensure continued American leadership in quantum information science. NIST also contributes to the whole-of-government initiative by detailing a staff member to the National Quantum Coordination Office (NQCO).

3.4. Recommendations

The VCAT recommends the Institute prioritize the following areas where NIST has the expertise and capability to make significant contributions:

- *Data frameworks and structures:* There is great power in collecting and aggregating publicly available data. NIST has the capability to provide guidance via framework(s) that can make such aggregations broadly useful to governments, academia, civil society, and the private sector.
- *Supply chain transformation:* NIST can play a vital role in software development, such as creating ways to improve software testing, verification, and development. A use case for such piloting could be addressing the need to re-platform software to support supply chain logistics. The supply chain could also be revolutionized by taking advantage of the power of 5G and advanced communications to enhance the global supply chain.
- *Cloud computing:* Our society is increasingly reliant on cloud computing to store, access, and manipulate data. We encourage NIST to consider updating foundational guidance produced in 2011-2012 to reflect modern cloud architectures and technologies and increasing their work in this area to meet future challenges.
- *Non-personal data (NPD)*: While information that permits the identity of an individual to be inferred (Personal Identifiable Information, PII) is regulated by state laws, NPD generated from IoT sensor data, aerospace sensors, etc. are far less regulated, yet hold the potential to drive nefarious or prosocial usage. VCAT suggests that NIST could help address key aspects in this area.
- *NIST frameworks:* NIST should consider continuing to develop efforts to maintain the progression of AI, CSF, and Privacy frameworks to ensure they are “living” documents that remain valuable and relevant in these rapidly advancing fields.
- *Power consumption:* As critical and emerging technologies progress, power consumption is likely to increase. Current technologies both for computing power and bioreactors require increased energy demands for the areas where centers are established. Measurement of these increased demands is needed, as well as R&D to develop more energetically sustainable technologies.

4. Ensuring U.S. leadership in International Standards for Critical and Emerging Technologies

NIST has an opportunity to bolster private sector and academic participation in international standards development for CETs. As a primary actor in national and international standards, NIST can exercise its convening authority to increase collaborative engagement in support of U.S. national and economic security.

The VCAT notes that NIST has made U.S. participation in international standards development activities a top priority and supports increased NIST engagement on technical standards in international bilateral and multilateral for a, including the G7, the U.S.-E.U. Trade and Technology Council (TTC), and the Quadrilateral Security Dialogue.

Many CET technologies are still premature and not ready for standardization; however, their innovation and development cycles are increasingly more rapid. Therefore, many Standards Developing Organizations (SDOs) are proactively establishing technical working groups at a much earlier stage in the CET innovation cycle. Strategic competitors, that employ a top-down government-led approach, are currently leveraging their resources to establish a foothold in certain SDOs for CETs.

Exercising strong U.S. standards development leadership requires thoughtful U.S. government engagement. The ability to lead U.S. standards development on the international stage rests on the U.S. government's ability to encourage private sector engagement. Standards development activities require long-term strategies and coordination across multiple stakeholder groups. NIST is in a prime position to support standards coordination activities; for example, NIST plays an internationally well-recognized and critical role in the selection of post-quantum encryption and digital signature standards. This approach can be modeled and scaled for other CET areas.

4.1. Recommendations

- NIST's approach to international standards engagement and leadership must rest on its core strengths—scientific and technical rigor in support of measurement science. Through new, innovative public-private partnerships, NIST can convene stakeholders across government, industry, academia, and civil society with the shared goal of supporting U.S. competitiveness and innovation.
- In close coordination with the American National Standards Institute (ANSI), NIST should establish new ways to assert U.S. leadership and actively promote U.S. standards in the international fora. This includes formal SDOs such as ISO, IEC, and the ITU as well as industry consortia such as 3GPP, O-RAN, IETF, and many more. .
- The U.S. government has increasingly viewed international CET standards development as an issue of national and economic security. NIST needs to facilitate additional multistakeholder engagement (private sector, government, civil society) in support of U.S. national and economic security.

5. Manufacturing Leadership

A partner to the U.S. manufacturing sector for more than a century, NIST has a proven track record in delivering useful tools and technical assistance that existing manufacturers and aspiring start-ups need. Timely technical assistance from NIST can help the nation's manufacturers to invent, innovate and create new products and services more rapidly and more efficiently than their competitors around the world. NIST's manufacturing programs include research efforts in the NIST laboratories, the Hollings Manufacturing Extension Partnership (MEP), Manufacturing USA, the CHIPS Program Office, and the CHIPS R&D Office:

- NIST laboratory programs continue to support the underpinning research, measurements, and standards to advance manufacturing. For example, the Institute's work on additive manufacturing includes a benchmarking test system, AM-Bench, that engages other federal agencies, universities, and private sector participants to solve technical challenges.
- MEP facilitates and accelerates the transfer of manufacturing technology in partnership with industry, universities and educational institutions, state governments, NIST laboratories, and other federal research laboratories and agencies. The VCAT recommends continuation of the new MEP National Network Strategic Plan for FY 2023-2027 focus on supply chain, workforce, and innovation/technology adoption.
- NIST continues to play a critical role in coordinating the Manufacturing USA network of institutes, including providing pandemic response awards under the NIST Rapid Assistance for Coronavirus Economic Response (RACER) Competition that funded 13 projects at 8 institutes, involving more than 80 partner organizations.
- The NIST-sponsored institute NIIMBL (the National Institute for Innovation in Biomanufacturing Pharmaceuticals) is making substantial progress. A NIIMBL report published in October established a new set of "biomanufacturing readiness levels" that provides a common approach to classify biomanufacturing developments throughout their life cycle, to provide a structure for assessing these new technologies.

The CHIPS and Science Act of 2022 provides the U.S. Department of Commerce with $50 billion for a suite of programs to strengthen and revitalize the U.S. position in semiconductor research, development, and manufacturing. The CHIPS Program Office released its first funding opportunity, which seeks applications for projects for the construction, expansion, or modernization of commercial facilities for the front- and back-end fabrication of leading-edge, current-generation, and mature-node semiconductors, in February 2023. Later in 2023, the CHIPS Program Office will release separate funding opportunities for semiconductor materials and manufacturing equipment facilities, and for R&D facilities. These investments will be key to restoring U.S. leadership in semiconductor manufacturing, supporting good-paying jobs across the semiconductor supply chain, and advancing U.S. economic and national security.

5.1. Recommendations

The VCAT supports the NIST's focus on advanced manufacturing and provides the following suggestions to strengthen the ongoing efforts:

- NIST should consider better leveraging the workforce development initiatives in MEP and Manufacturing USA by, for example, integrating them into an MEP Center's "staging-up" program that each center undergoes when designated as an MEP Center.
- VCAT supports the MEP Advanced Tech Team concept of staff that act as an "easy button" solution of resources available to MEP Center field staff and encourages the expansion of the Advanced Tech Team to include more champions in centers across the U.S.
- VCAT encourages NIST to evolve the Manufacturing USA program into a fulsome network model that allows more shared resources than the current operational structure can accommodate.
- VCAT notes that the CHIPS and Science Act will also usher a significant technology transfer program at NIST by providing significant funds for Small Business Innovation Research and Small Business Technology Transfer programs. VCAT recommends leveraging these investments, including through both intramural research and external manufacturing programs, as a tremendous opportunity for NIST to stimulate U.S. innovation.
- NIST laboratories should continue coordinating and leveraging efforts with MEP and Manufacturing USA.

6. Ensuring NIST is Fully Resourced to Deliver on its Mission

NIST's success relies on its people, first and foremost, but it also needs world-class facilities. For NIST to excel, it must be fully resourced to address its failing infrastructure, be competitive when recruiting and retaining talent, and fully executing mission projects. While specific examples in need of full resourcing are noted below, VCAT recommendations for sufficient resources are not limited to this list.

6.1. Mission Delivery

The NIST Center for Neutron Research (NCNR) is a national resource for research using thermal and cold neutrons that has enabled an enormous body of research and has trained many hundreds of Ph.D. students. It is one of the nation's premier neutron research facilities serving over 2,500 researchers from 165 organizations and labs.

The National Construction Safety Team (NCST) Act was signed into law in 2022 and authorizes NIST to establish teams to investigate building failures. NIST is currently investigating the effects of Hurricane Maria on Puerto Rico, with a progress report released in January 2021, as well as a technical investigation on the partial collapse of the Champlain Towers South condominium in Surfside, Florida.

iEdison (or interagency Edison) is an online, relational database designed around the reporting requirements of the Bayh-Dole Act and its implementing regulations. It allows recipients of federal research funding to report subject inventions and patents to the federal funding agency that issued the funding award. A new system was launched on August 9, 2022, with significantly improved capabilities, functions, and usability. Since the relaunch, over 5000 inventions and over 9000 patents have been logged. More agencies are now using iEdison as well. In 2023, the development team (NIST, USPTO, NIH, and others) were recognized with the Interagency Partnership Award for Technology Transfer from the Federal Laboratory Consortium (FLC).

6.2. Facilities

VCAT recognizes that the state of NIST's facilities has become a critical problem that is materially harming the agency's ability to deliver on its mission. The VCAT recommends increases in appropriations to halt and reverse the accelerating breakdown of NIST's facilities and physical plant capabilities. As requested in the Consolidated Appropriations Act of 2021 (P.L. 116-260), NIST's Office of Facilities and Property Management (OFPM) contracted with the National Academies of Sciences, Engineering, and Medicine's (NASEM's) Board on Infrastructure and the Constructed Environment to examine the state of NIST's facilities and utilities infrastructure (e.g., power, water, steam) and to determine which are impacting NIST's mission the most and/or are in greatest need of repair. The study also was tasked to assess what would be needed to restore NIST's facilities and utilities to current standards of acceptable performance.

The NASEM committee conducted an extensive review of NIST facilities and visited NIST's Gaithersburg and Boulder sites to tour a variety of laboratory facilities in each location. The committee members also met with representatives from the Johns Hopkins University Applied Physics Laboratory and with representatives of three government agencies: the National Institutes of Health, the Army Corps of Engineers' Engineer Research and Development Center, and the Department of the Interior. After publishing their report on February 7, 2023, representatives of the NASEM committee briefed the VCAT on its contents during the VCAT's February meeting.

The alarming main point of the presentation to the VCAT is captured in the following quote from the report's executive summary:

> "The committee's investigations have found that facility issues are preventing NIST from achieving its mission, that valuable researcher time is being wasted due to inadequate facilities, and that in many cases NIST facilities are no longer world class."

Furthermore, the poor condition of NIST's facilities and utilities is reducing NIST staff productivity by an estimated 10 % to 40 %. Utility failures such as water and steam line leaks have damaged or destroyed high-precision laboratory equipment costing millions of dollars, including the Kibble balance that was used to help redefine the kilogram. Additionally, NIST projects have been put on hold for as long as 18 months, as was the case of the quantum entanglement work that Physics World named the 2021 Breakthrough of the Year.

NIST currently has a deferred maintenance backlog of over $800 million. Without sustained and sufficient investment, NIST faces an increased probability 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. As stated in the NASEM report:

> "The root cause of this troubling situation is at least 20 years of inadequate federal government funding for the sustainment, restoration, and modernization of NIST's aging and outdated facilities. Correcting the situation now requires $5 billion over at least 12 years, not counting inflation."

NIST staff have worked extensively to compensate for and work around their facilities and utilities issues. While this "going above and beyond" work is admirable, it should not be the primary focus of NIST scientists and engineers, it has masked the breadth and depth of the problem, and it is not sustainable. Degraded facilities create health and safety issues; for example, NIST staff have been forced to construct ad-hoc systems to catch rainwater that intrudes into office and lab spaces from leaking roofs.

Ubiquitous and obvious signs of decay such as these hamper NIST's ability to recruit and retain the highly skilled talent that it needs to fulfill its critical mission. The job market in CET sectors is incredibly competitive. Without state-of-the-art facilities to match cutting-edge research, NIST will be unable to attract talent and maintain U.S. leadership in CETs.

6.3. Visibility

Because NIST's work covers a very broad range of scientific and engineering fields, affecting many sectors of the U.S. economy, and involves partnerships with academia and other government agencies, NIST needs to interact with a large and diverse set of stakeholder groups. In addition, NIST needs the engagement and support of the public and its representatives in the U.S. Congress to ensure that it has the necessary resources to carry out its mission.

The issues with NIST's facilities and the need for increased resources require NIST to convey the importance of NIST's mission, the threat to that mission from the poor condition of NIST's facilities, and the urgent need for increased funding to address the problem, to decision makers in the U.S. Congress. Increasing and improving NIST's visibility will be central to this effort. Because NIST's work advancing measurement science touches on so many varied technical disciplines and affects many sectors of the U.S. economy, the agency must deal with an exceptionally large and diverse set of stakeholders that includes multiple industries, standards development organizations, legislative bodies, other government agencies, academic institutions, and the U.S. public.

The VCAT acknowledges the significant efforts of NIST to conduct outreach and spread information about NIST programs, such as:

- The Public Affairs Office (PAO) deals exclusively with outreach and its goal is to help the NIST Director focus on agency priorities. The PAO manages NIST branding and provides resources for presentations, provides promotional print materials (e.g., the Measurement League comics), and provides workshops for NIST staff on how to interact with the media. The PAO recently completed a multi-year process to simplify NIST's branding and is actively engaging with social media.
- The Office of Congressional and Legislative Affairs Office (CLA) outreach is focused on interactions with members of Congress and their staff, as well as government affairs representatives for standards development, university, and industry associations.
- NIST's operating units, including its laboratories, MEP, and Manufacturing USA, pursue their own outreach efforts aimed at their respective constituencies.

NIST has previously explored the creation of a foundation, similar to the Foundation for the National Institutes of Health (FNIH), which is a non-profit, 501 charitable organization that the U.S. Congress created in 1990. A NIST analog to the FNIH could serve as a grant-giving entity that also supports educational programs, along with awards and other events that would raise NIST's profile with legislators, their staffs, and the public.

6.4. Resources

The NIST budget does not include full resources to address the needs of the Institute in accomplishing its mission. While VCAT applauds the funding increases provided by Congress in the FY 2023 Omnibus Appropriations bill (see Budget section), the presence of significant directed external funding (earmarks) puts NIST at risk. These earmarks dramatically increased from FY 2022 to FY 2023 with no significant accompanying increase in appropriations for NIST base funding. The costs for administering and overseeing these externally directed projects, some of which have little to no relevance to NIST's mission, cannot be adequately accommodated in the current budget without a decrease in grants management capacity for other (NIST-mission driven) awards.

Due to failing infrastructure, increased external earmarks, and increased competition for workforce, NIST will need to make deliberate decisions about what programs to halt to continue to deliver on mission priorities. We recognize the difficulties in such decisions, particularly because NIST staff are highly specialized and cannot easily transition to other subject areas. However, with failing infrastructure and insufficient funding, these tough choices will have to be made more increasingly unless the funding gaps are addressed. This will have major consequences to the NIST mission delivery unless additional funding and staff can be secured.

6.5. Recommendations

- VCAT applauds the significant NIST effort to implement necessary corrective actions, effectively and swiftly, following the safety incident at the NCNR on February 3, 2021. VCAT recommends continued support for the NCNR to maintain operations and to provide resources for critically needed repairs and new staff to revitalize operations.
- VCAT recommends that NIST work with the Department of Commerce and relevant House and Senate appropriators to attain sufficient base funding for NCST Act investigations, so that the Engineering Laboratory will not have to redirect its staff from ongoing research and operations. Further, given the increasing prevalence of natural disasters, NIST's measurement and analytic capabilities should be expanded to assist in the development of modern building standards considering safety threats posed by violent windstorms, fires, and coastal flooding.
- VCAT recommends that NIST work with the Department of Commerce and relevant House and Senate appropriators to attain sustained funding for iEdison to maintain its current operations and expand its capabilities to better support stakeholders and the U.S. taxpayers.
- The NASEM report on NIST's facilities proposed a series of recommendations for NIST to clear its maintenance backlog, and to restore its facilities and utilities to a state that will ensure that the United States has a world-leading National Measurement Institute well into the future. The VCAT endorses these recommendations and encourages the leadership at NIST, DOC, Congress, and the Administration to move forward with the implementation of the recommended recovery plan expeditiously.
- The VCAT recommends any future external earmarks should include budget support for their management, such as appropriations that allow for up to 5 % "tax" holdback for managing the earmarks.
- VCAT recommends that NIST continue to engage with prominent content generators with large numbers of subscribers, such as the Veritasium channel on YouTube, to leverage internal work to a broader audience. For example, two videos on NIST's work that resulted from a visit by a film

crew for that channel pulled in millions of views in just a few days, with uniformly positive comments from the viewers.

- The VCAT encourages NIST to pursue the establishment of a foundation, as an additional tool that would lead to greater awareness of, and support for, the agency and its mission.

7. Building a Community Where Everyone is Safe, Valued, Supported, Engaged, and Empowered

NIST needs its people more than ever to deliver on critical mission efforts, and it needs to create an environment where they can thrive. Employees must feel safe, both physically and mentally, in the office and laboratory. Employees of all backgrounds must be valued. A sense of community, whether virtual or in-person, is vital to the engagement and health of the workforce.

7.1. Safety

NIST continues to provide regular updates on safety at the beginning of every VCAT meeting, including performance metrics and the status of recent incidents, as well as forward-looking efforts to build a NIST Safety Culture Program. The Institute is embarking on a safety culture development journey that will be essential for the future of the organization. NIST is currently undergoing significant actions to address its physical safety culture by collecting expert recommendations and data, for example by the NIST Director's establishment of a NIST Safety Commission and by administering a staff-wide survey. The Office of Safety, Health, and Environment (OSHE) is implementing a substantial communications plan that includes weekly emails, videos, and a newsletter.

7.2. Diversity, Equity, Inclusion, and Accessibility

The Executive Orders related to diversity and equity highlight the need for NIST to continue working on developing equity and inclusion within the Institute and ensuring that NIST's population represents the American people. The FY 2022-2024 NIST DEIA Strategic Plan lays out five priority areas – diversity, equity, inclusion, accessibility, and inclusive economy. Internal work was recently completed with over 200 staff volunteering their time to create action items and milestones under the priority areas. The NIST DEIA Strategic Plan requires support from the highest level of the agency to meet mission goals. Efforts such as the new recruitment and outreach strategies and the DEIA Dashboard to increase participation and track progress metrics should continue to be supported.

7.3. Community Building

NIST, like every other organization, is facing the challenge of post-pandemic operations. Staff are not returning to their offices for many reasons which include failing infrastructure, the lack of amenities on campus, and concerns about health and safety – both physical and emotional. NIST started a community building group to develop and help execute a plan of actions that fosters workplace interactions with the purpose of improving the work culture. Actions will include the creation of events, spaces, practices, and wellness programs aimed specifically at fostering positive workplace aspects. VCAT recommends using

this as an opportunity to foster leadership in its staff, identifying individuals who can bring people together to lead the way to the new working environment. This new workplace may have elements of the past but will need to meet people where they can contribute most effectively to the NIST mission.

7.4. Workforce

With global emphasis on semiconductors, AI, cybersecurity, and biotechnology, the competition for talent is dramatically increasing. For NIST to compete with the private sector, additional hiring and pay authorities may be needed to recruit the level of talent needed to support NIST's major research efforts and to sustain strong operational capacity.

7.5. Recommendations

- VCAT recommends that NIST look systemically across safety investigations to identify holistic changes to safety procedures and the culture that could benefit a wider population. VCAT acknowledges the comprehensive approach that NIST is undertaking to ascertain and address vulnerabilities in the safety culture and applauds the Director's swift actions to date.
- VCAT recommends that NIST develop strategies and programs to continue to expand the diversity of recruitment to include populations such as people who have paused their careers or mid- and late-career people who desire a career change. NIST should also explore ways to revitalize the workplace environment to attract new talent in the CETs and in the services that keep an organization running such as administrative, procedural, and facilities staff.
- The VCAT recommends exploring critical pay authority and other tools to recruit talent in critical and emerging technologies for NIST to support the needs of the U.S. through mission delivery.
- The VCAT recommends that NIST establish or partner with programs that strengthen the student-to-hire pipeline, building on efforts that will be initiated with new funds in FY 2023.
- VCAT notes that there are currently gaps between the skills needed in manufacturing and the skills that students gain in their education/training, and suggests that NIST programs like MEP and Manufacturing USA are uniquely positioned to help address these gaps.

8. NIST Budget

The passage of the CHIPS and Science Act included significant programmatic growth for NIST and set authorization levels that increase in each of the coming years. The NIST for the Future Act (the Act), included as part of the CHIPS and Science Act authorizes and codifies the NIST role in many areas including bioscience and biotechnology, cybersecurity and privacy, greenhouse gas measurements, advanced communications, and international standards development. The Act also provides additional NIST flexibilities for hiring and operations and calls on NIST to work with the National Science Foundation, Department of Energy, and other Departments and Agencies. The Act authorizes funding levels that gradually increase over five years to $2.28 B and nearly doubles the total budget for NIST (see Figure 1).

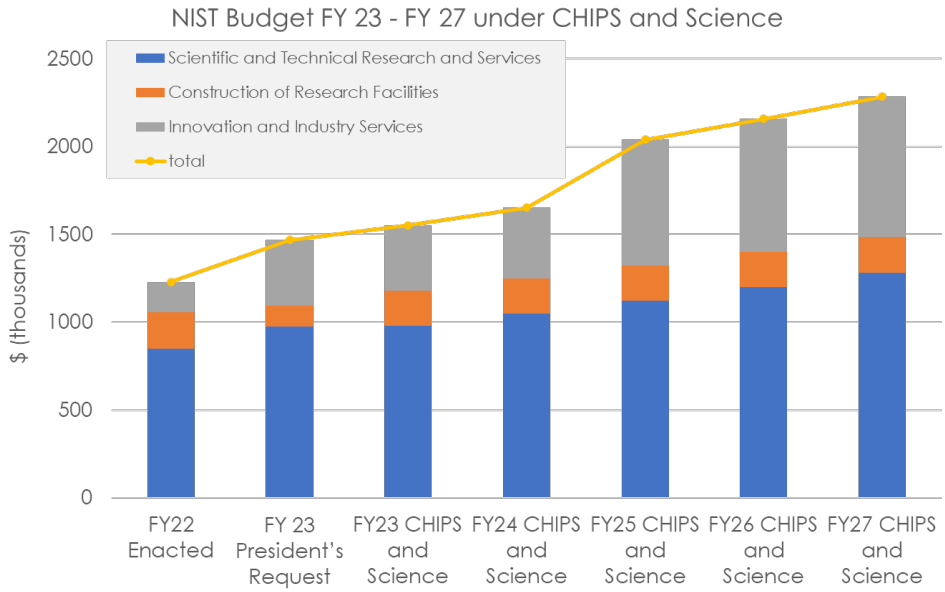

Figure 1. Figure showing CHIPS and Science Act authorizations for NIST, as presented to VCAT in October 2022. Earmarks are not included. This show a 50 % growth in Scientific and Technical Research Services, a 358 % growth in Industrial Technology Services, and -3 % growth in Construction of Research Facilities

VCAT recognizes overall increases to NIST programs in the FY 2023 enacted budget, including the Scientific and Technical Research and Services (laboratories, +$78.1 M); the Innovation and Industry Services programs MEP (+$17.0 M) and Manufacturing USA (+$20.5 M); and Construction of Research Facilities (+$50.0 M)[1]. Congress provided funding for laboratory increases including to support standards for critical and emerging technologies, cybersecurity and privacy, artificial intelligence, and climate and energy measurement tools and test beds. Supplemental funding (one-time) was also provided for NIST to continue ongoing disaster investigations ($40.0 M), and to support new authorities and directions to MEP and Manufacturing USA enumerated in the CHIPS and Science Act ($13.0 M and $14.0M respectively). Nonetheless, the funding is insufficient given the expansion of NIST's mission and need for substantial facilities improvements.

However, the process of including external earmarks in the NIST laboratories and construction accounts, which restarted in FY 2022, puts the Institute at risk. These "community projects" are directed by Congress and do not increase the base funding for NIST; when the administrative burden is taken into account, these external projects have a net negative impact on base NIST funding. For NIST to sustain, let alone grow, their scientific capabilities, base funding must be increased to ensure continued delivery of services and research. In FY 2023, the laboratories appropriated budget (Scientific and Technical Research and Services) includes $62.5M in 34 projects. The facilities appropriated budget (Construction of Research Facilities) contained 31 projects totaling $332.2 M.

As shown in the table below, the FY 2024 President's Budget Request increases NIST funding across the institute's programs. After accounting for Congressionally directed spending in the FY 2023 budget, the President's FY 2024 budget request for NIST provides an increase of $358.5 million (+29%) to support

[1] The FY 202 3 budget allocation has not yet been finalized with Congress at the time of writing.

mission critical programs at NIST including a substantial increase to begin addressing critical NIST facility needs, expand cutting-edge research, ensure NIST's manufacturing programs strengthen domestic supply chains, and address critical workforce gaps. The increase positions NIST to address priorities in advanced research for critical and emerging technologies, cybersecurity and privacy, climate and the environment, and trustworthy supply chains, while ensuring exceptional mission delivery.

Table 2. NIST Budget (dollars in millions)

Activity	FY 2022 Enacted	FY 2023 Enacted	FY 2024 President's Request
Scientific & Technical Research Services (STRS)	$850.0	$953.0	$995.0
Industrial Technology Services (ITS)	$174.5	$212.0	$374.9
Construction of Research Facilities (CRF)	$205.6	$462.2	$262.1
Total, NIST Discretionary	$1,230.1*	$1,627.3*	$1,632.0

** Excludes one-time supplemental funds.*

The FY 2024 President's Budget targets increased funding for mission-essential projects:

- Ensures a strong foundation for future standards development by investing in critical and emerging technologies research, measurements, and data.
- Provides resources for NIST to meet increased industry and government demands for cybersecurity and privacy-related standards and guidelines.
- Supports new technology solutions, data, and measurements to mitigate climate change.
- Enhances and improves NIST mission delivery and stakeholder engagement.

The FY 2024 President's Budget includes modernization to the Gaithersburg Central Utility Plant (CUP) to install sustainable systems, increase capacity, and enhance centralized control and monitoring. NIST will also address maintenance backlogs, modernize IT networks, and replace multiple heating, ventilation, and air conditioning (HVAC) units/systems.

The FY 2024 President's Budget includes increases for Manufacturing USA (+$60.3 M) to provide critical support for the network's institutes and the creation and operation of testbeds, support for technology transfer in emerging priority areas, and engagement with underserved communities. MEP funding (+$100.9 M) is requested to accelerate progress for supporting a focused, national effort that strengthens U.S. manufacturing and empowers small and medium-sized manufacturers by narrowing the workforce gap, mitigating supply chain vulnerabilities, and leveraging advanced technology.

8.1. Recommendations

The VCAT notes the increases to NIST programs in the FY 2023 appropriated budget, and proposed growth in the President's FY 2024 Budget Request. However, we note the following:

- VCAT has serious concerns about the negative effects of increased external earmarks on NIST's operations and instead recommends that the external earmark funding be re-directed to base

NIST funding in both the Scientific and Technical Research and Services and Construction of Research Facilities accounts so that NIST can continue to meet its critical mission for the United States.

- VCAT recommends growth in the NIST budget consistent with, or greater than, the authorizations passed as part of the CHIPS and Science Act.