NATIONAL ACADEMIES Sciences Engineering Medicine

Technical Assessment of the Capital Facility Needs of the National Institute of Standards and Technology

Aerial view of NIST Gaithersburg Campus, NIST Public Affairs Office (PAO)

REPORT RELEASE WEBINAR – FEBRUARY 7, 2023

The Committee

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Statement of Task

At the request of the National Institute of Standards and Technology (NIST) Office of Facilities and Property Management (OFPM), [the National Academies] shall convene an ad hoc study committee that shall investigate the following four (4) focus areas:

1. Identifying the NIST facilities and utilities infrastructure in greatest need of recapitalization, of repair, and of those most impacting the research mission's implementation;
2. Assessing the composition of individual capital and repair projects to bring the NIST Gaithersburg, Maryland and Boulder, Colorado campuses' research and support facilities and utilities infrastructure up to current standards of acceptable operational performance to meet their assigned mission objectives;
3. Evaluating at a high level the completeness, accuracy, and relevance of cost estimates (already developed by/for NIST) for proposed individual capital and repair projects; and
4. Identifying potential factors and approaches that NIST should consider in developing a comprehensive capital strategy for its two campuses' portfolio of facilities and utilities infrastructure.

Statement of Task, cont.

The study shall consider and identify approaches based on five (5), ten (10), fifteen (15), and twenty (20) year prioritization outlooks.

In addition, to better inform capital facility planning and operational sustainment of NIST's two campuses, the ad hoc study committee shall review comparable available facility condition methodologies and metrics of other historically designated federal agencies at an overall portfolio level, and provide recommendations in determining the minimum levels of funding (two components – for individual building and utility infrastructure capitalization/re-capitalization and for the campuses' overall annual operations/maintenance/repair [OMR] needs) required to sustain NIST's assets at an overall portfolio level.

Bottom Line Up Front

Finding 3-4: NIST facilities are not world class and are therefore a growing impediment against attracting and retaining staff in a highly competitive STEM environment. Moreover, the longstanding facilities problems have created a culture of workarounds by scientific staff that distracts from R&D efforts.

Based on the laboratory tours and discussions with researchers, the committee estimates overall technical staff productivity losses of 10%-40% due to rework, repairs, and workaround efforts by the researchers.

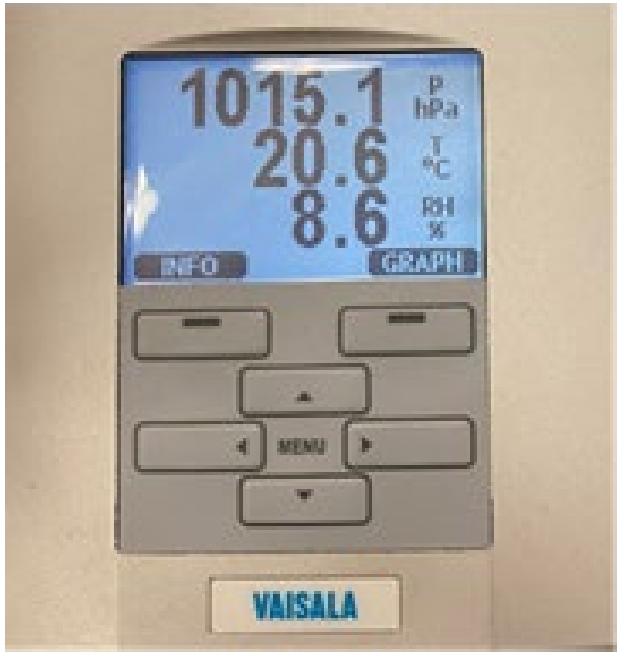
Recommendation 4-5: OFPM's entire NIST Coordinated Recovery Plan, both the Sub-Plan for Recapitalization (CMR-funded) and the Sub-Plan for Stabilization (SCMMR-funded), should be approved and fully funded beginning in FY 2023, subject to continuing refinement.

NOTE: CMR, Construction and Major Renovations; SCMMR, Safety, Capacity, Maintenance, and Major Repairs

Example: Lack of Humidity Control Stopping Work

NIST provides Standard Reference Materials for gases that are subject to regulation, such as greenhouse gases (for example, carbon dioxide and methane), emission gases (for example, nitric oxide and sulfur dioxide) for the Environmental Protection Agency (EPA), as well as special needs for law enforcement (e.g., ethanol for breathalyzers). Between October and March, low humidity creates static charge that renders a critical instrument inoperable. As a result, customers may be forced to wait up to 6 months for measurements and risk being out of compliance with EPA standards. A 2002 economic analysis found that this activity yielded a benefit-cost ratio (BCR) of 24:1.

(Median BCR for NIST work is 9:1. A BCR of 3:1 is significant in industry.)



Gauge showing low relative humidity in a NIST laboratory, NIST PAO

Key Takeaways

- The National Institute of Standards and Technology's (NIST's) potential to help the Nation is drastically hindered by the "alarming" and "critical" state of funding for the sustainment, restoration and modernization of NIST's facilities.

- NIST researchers have continued to deliver world-class research by dint of heroic dedication, often fighting the poor condition and lacking functionality of their own facilities to do their jobs.

- Solving NIST's unsatisfactory facilities situation requires immediate, top-down attention and resolute action by leaders of NIST, the Department of Commerce (DOC), and Congress.

Key Takeaways, cont.

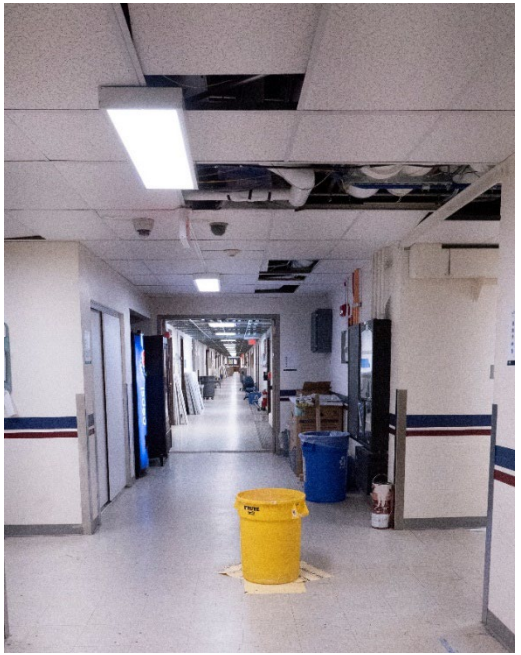
- OFPM uses good practices for planning, programming and budgeting, but past budget requests submitted by the President to Congress have sought funding for only a fraction of their needs.

- OFPM has formulated plans to address the facilities situation at NIST. The committee believes these plans are the right approach and should be funded and implemented as soon as possible.

- Failing to repair and recapitalize NIST's facilities puts NIST's mission at risk, impacting public safety, national security, and the U.S. economy.

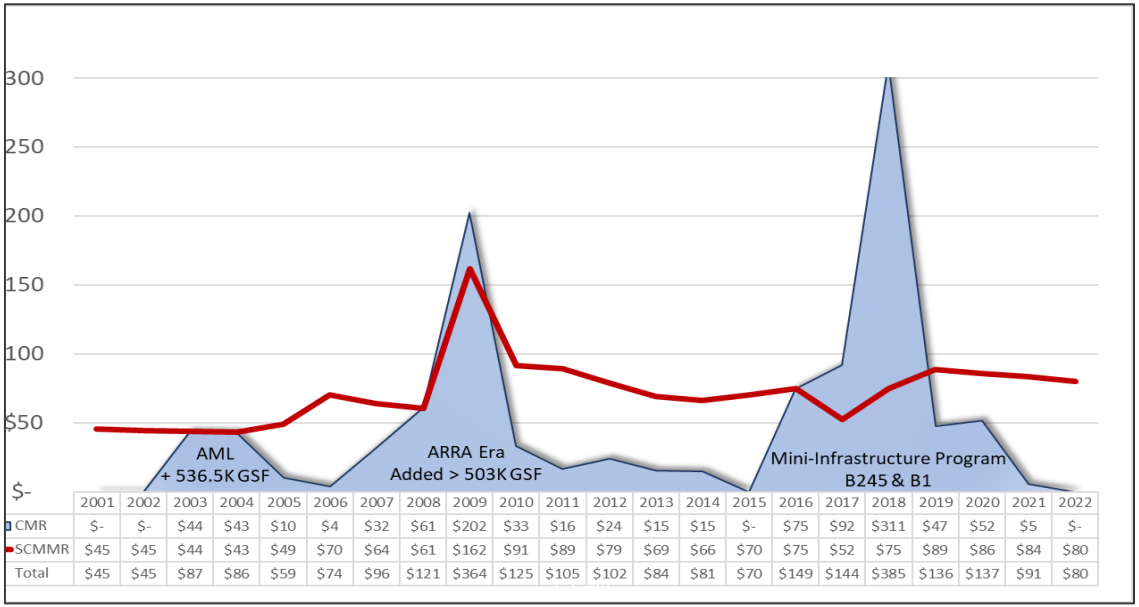
Example: Roof Leak Destroys Equipment

The semiconductor industry is of critical importance to the U.S. The nanoscale reliability laboratory is instrumental in analyses that support wafer fabrication. Due to a leaking roof an electron microscope was put out of commission for 6 months for repairs, and undetected corrosion subsequently caused a fire in the high-voltage (220 kV) drive circuitry, destroying the microscope entirely. The replacement cost for this electron microscope is estimated at $2.5 million. A lack of attention to roof maintenance took a vital, expensive instrument offline and led to its eventual destruction.



Barrel catching water from a ceiling leak at the Boulder Laboratories, NIST PAO

Historical NIST Capital Funding



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
CMR	$-	$-	$44	$43	$10	$4	$32	$61	$202	$33	$16	$24	$15	$15	$-	$75	$92	$311	$47	$52	$5	$-
SCMMR	$45	$45	$44	$43	$49	$70	$64	$61	$162	$91	$89	$79	$69	$66	$70	$75	$52	$75	$89	$86	$84	$80
Total	$45	$45	$87	$86	$59	$74	$96	$121	$364	$125	$105	$102	$84	$81	$70	$149	$144	$385	$136	$137	$91	$80

FIGURE 4-2 NIST's 20-Year Capital Funding History converted to 2022 $US. SOURCES: The Office of Facilities and Property Management and data from Construction Analytics, 2022, "Construction Inflation 2022," Construction Analytics, Updated May 3, 2022, https://edzarenski.com/2022/02/11/construction-inflation-2022/. NOTES: AML, Advanced Measurement Laboratory; ARRA, American Reinvestment and Recovery Act; CMR, Construction and Major Renovations; SCMMR, Safety, Capacity, Maintenance, and Major Repairs

OFPM Draft Recovery Plan and Necessary Funding Levels (Fiscal Year 2022 dollars)

NIST OFPM has a two-pronged plan:

- Sub-Plan for Stabilization (SCMMR-funded)
- Sub-Plan for Recapitalization (CMR-funded)
- Approximately 12-year period

TABLE 4-1 Overview of NIST Facility and Infrastructure Funding Needs

Funding Component	Amount Needed Annually
Construction and Major Renovations (CMR)	$300 million to $400 million
Safety, Capacity, Maintenance, and Major Repairs (SCMMR)	$120 million to $150 million
Total needed for Construction of Research Facilities (CRF)	$420 million to $550 million

NOTE: CRF funding is the sum of CMR and SCMMR funding. SOURCE: OFPM Point Paper “NIST Facilities Summary for Representative Trone, June 2022”.

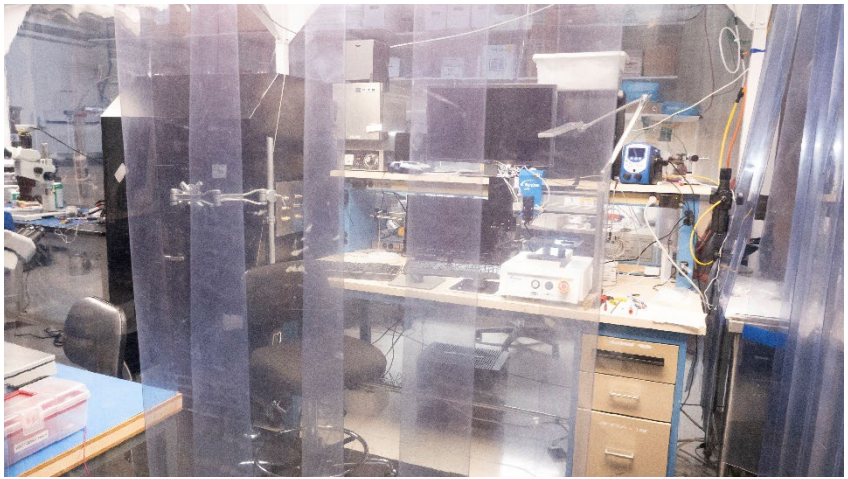
Recommendations – Existing Facility Conditions

Recommendation 3-1: NIST should modernize laboratory facilities to provide the performance needed to meet the measurement science and mission-focused R&D challenges for today and the future, and to attract and retain the scientists and engineers required to solve these challenges. Current conditions and functionality are adversely impacting NIST's current mission and modernization is well overdue and desperately needed.

Recommendation 3–2: NIST should address the underlying deficiencies with campus infrastructure including the central utility plants, distribution systems, and electrical power quality and continuity to ensure that the modernization plan investment is effective. If not developed in conjunction with laboratory modernization, the requirements of the new laboratories will continue to not be met.

Example: Lack of Humidity Control Impacts National Security

The Quantum Sensor Laboratory in Boulder has developed unique superconducting X-ray and gamma ray spectrometers for materials analysis and telescope arrays. NIST provides these devices to U.S. government agencies for security applications in nuclear materials identification. Deliveries to Idaho National Laboratory and Los Alamos National Laboratory were repeatedly delayed with the delays traced to low humidity during packaging.



Enclosed workspace in the Quantum Sensor Laboratory, NIST PAO

Recommendations – Sustainment, Restoration, and Modernization of NIST'S Existing Facilities

Recommendation 4-1: NIST and DOC leadership should ensure that the leadership of the DOC, Office of Management and Budget (OMB), Office of Science and Technology Policy (OSTP), and the House and Senate Appropriations and Oversight Committees are fully aware of NIST's facility needs and the national consequences of not meeting those needs. So that OMB, OSTP, and Congress can fully support NIST in recovering from its unsatisfactory facility situation, NIST and DOC should also consider:

- Establishing practices that prevent or fully mitigate the diversion of appropriated NIST CRF funds to non-NIST organizations and to other purposes within NIST, e.g., Institutional Support taxation for CRF spending and the burdensome insertion of information technology network requirements into the CRF budget.
- Requiring semi-annual follow-up verification and accountability from NIST to ensure that adequate funding is provided and implemented for annual sustainment, restoration, and modernization requirements, and that increased annual investments in CRF backlog reduction and facility sustainment, restoration, and modernization of NIST's existing facilities are spent as intended and optimize their return in terms of meeting the nation's economic and security challenges.

Recommendations – Sustainment, Restoration, and Modernization of NIST'S Existing Facilities, cont.

Recommendation 4-2: NIST should improve its communication of the impacts on taxpayers and consumers of inadequate appropriations of CRF funding. To make its CRF budget justifications and other communications more compelling and accurate, greater input and collaboration is necessary from NIST scientists, facilities officials, and budget and communications staff, working together.

Recommendation 4-3: NIST and DOC should increase and intensify efforts to advocate that Congress invest fully in NIST's Coordinated Recovery Plan beginning in FY 2023 to restore NIST's existing portfolio to a functional status while continually updating the Recovery Plan. NIST and DOC should annually ensure that the Recovery Plan's annual investment amounts and NIST budget requests are appropriately adjusted to reflect actual and projected inflation rates as well as refined cost estimates.

Recommendation 4-4: OFPM should continue refining and updating its Draft Coordinated Recovery Plan. The purpose of such continued refinement would be to ensure that every year going forward reflects the latest inflation rates and collectively addresses all categories of funding requirements in a coordinated combination of CMR projects and SCMMR-funded work.

Recommendations – Sustainment, Restoration, and Modernization of NIST'S Existing Facilities, cont.

Recommendation 4-5: OFPM's entire NIST Coordinated Recovery Plan, both the Sub-Plan for Recapitalization (CMR-funded) and the Sub-Plan for Stabilization (SCMMR-funded), should be approved and fully funded beginning in FY 2023, subject to continuing refinement.

Recommendations – Practices of Portfolio Management and Capital Project Planning

Recommendation 5-1: OFPM has a sound Draft Recovery Sub-Plan for Recapitalization (CMR-funded) and should seek funding of $300 million to $400 million annually for at least 12 years to enable NIST to restore lost mission capabilities and provide facilities for new NIST programs.

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Example: 2021 Physics World Breakthrough of the Year in a Newly Renovated Laboratory

A demonstration project for quantum entanglement of microresonators (awarded the 2021 Physics World Breakthrough of the Year) was delayed 18 months until a suitable renovated laboratory could be located, a delay in a critical advance in the global race for quantum science superiority.

The newly renovated laboratory where the award-winning work was conducted, NIST PAO

Key Recommendations – Sustainable Ownership Strategies for the NIST Facility Portfolio

Recommendation 6-1: NIST should develop and maintain facility and infrastructure total cost of ownership standards for each unique facility and infrastructure type that identifies: (a) first cost, (b) annual operations costs (utility, security, custodial, safety, and janitorial), (c) sustainment costs, and (d) renewal (restoration and modernization) costs on a per unit basis as a baseline for identifying and forecasting the total cost of ownership for each new and existing facility, and supporting infrastructure with the resulting funding requirement identified as part of the overall research program needs.

Recommendation 6-2: NIST should expand its current real property asset management system and strategy beyond condition assessment and deferred maintenance reporting and provide a proactive, life-cycle approach to real property ownership for the NIST real property portfolio that aligns with the Federal Real Property Reform Act of 2016 and the associated framework by Government Accountability Office and the 2023 Academies report Strategies to Renew Federal Facilities.

WHERE TO DOWNLOAD THE REPORT

- A prepublication copy of report, still subject to editorial correction, is available at https://nap.nationalacademies.org/catalog/26684
- A final version of the report will be available at the same URL by February 28, 2023.

Aerial view of Boulder Laboratories, NIST PAO

Acronyms and Abbreviations

- AML Advanced Measurement Laboratory
- ARRA American Reinvestment and Recovery Act
- BCR benefit-cost ratio
- CRF Construction of Research Facilities
- CMR Construction and Major Renovations
- DOC Department of Commerce
- NIST National Institute of Standards and Technology
- OFPM [NIST] Office of Facilities and Property Management
- OMB Office of Management and Budget
- OSTP Office of Science and Technology Policy
- OMR operations/maintenance/repair
- PAO public affairs office
- R&D research and development
- SCMMR Safety, Capacity, Maintenance, and Major Repairs
- STEM science, technology, engineering, and mathematics