

VISITING COMMITTEE ON ADVANCED TECHNOLOGY
National Institute of Standards and Technology

2014 Annual Report

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

U.S. Department of Commerce

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VISITING COMMITTEE ON ADVANCED TECHNOLOGY
National Institute of Standards and Technology

Preface

The Visiting Committee on Advanced Technology (VCAT) of the National Institute of Standards and Technology (NIST) was established in its present form by the Omnibus Trade and Competitiveness Act of 1988 and updated by the America COMPETES Act in 2007. 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. In addition, the America COMPETES Act calls for the VCAT to comment on NIST's three-year programmatic plan in its annual report to Congress. This 2014 annual report covers the period from the beginning of March 2014 through February 2015.

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 Safety Systems and Culture
- Cybersecurity
- Disaster Resilience
- Advanced Communications
- Advanced Manufacturing

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, 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 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.

Three new members were appointed during the period covered by this report: Dr. Rodney Brooks (Rethink Robotics), Ms. Hemma Prafullchandra (HyTrust, Inc.), and Mr. Michael Garvey (M-7 Technologies)

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. Tony Haymet, Chair
University of California, San Diego
Term: September 1, 2009 - August 31, 2015

Dr. Darlene J.S. Solomon, Vice Chair
Agilent Technologies
Term: January 3, 2010 - January 2, 2016

Dr. Rodney Brooks
Rethink Robotics
Term : June 1, 2014 – May 31, 2017

Dr. Karen Kerr
Agile Equities, LLC
Term: June 1, 2011 - May 31, 2017

Dr. Sujeet Chand
Rockwell Automation
Term: April 1, 2010 - March 31, 2016

Dr. Pradeep Khosla
University of California, San Diego
Term: June 2, 2008 - June 1, 2014

Dr. Uma Chowdhry
DuPont (Emeritus)
Term: October 1, 2010 – January 18, 2015

Dr. Roberto Padovani
Qualcomm Technologies, Inc.
Term: May 1, 2011 - April 30, 2017

Dr. Rita R. Colwell
University of Maryland at College Park
Term: January 6, 2014 – January 7, 2017

Ms. Hemma Prafullchandra
HyTrust, Inc.
Term : October 27, 2014 - October 26, 2017

Mr. Michael Garvey
M-7 Technologies
Term : January 23, 2015 – January 22, 2018

Dr. Alton D. Romig, Jr.
Lockheed Martin Aeronautics Company
Term: April 15, 2009 - April 14, 2015

Mr. William M. Holt
Intel Corporation
Term: May 13, 2012 - May 12, 2015

Dr. Alan I. Taub
University of Michigan
Term: May 9, 2008 - May 8, 2014

Dr. John J. Tracy
The Boeing Company
Term: January 7, 2013 – January 6, 2016

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1. VCAT Focus in 2014

In 2014, the VCAT continued to focus on cybersecurity and NIST safety, building on the work subcommittees started in 2013. In addition, the VCAT spent 2014 focused on NIST's role in disaster resilience and emerging needs in advanced communications. This 2014 Annual report summarizes the VCAT's work, observations and recommendations in these areas. Also during 2014, the VCAT was briefed on activities NIST is conducting to ensure operational excellence and a culture of continuous improvement. The October 2014 meeting included a session on NIST scientific personnel trends and demographics with discussion on the current and future personnel authorities and policies needed to maintain a quality technical staff. The VCAT is pleased with NIST's commitment to ensuring the environment exists to attract, support, and retain a world-class scientific staff now and into the future.

The VCAT finds that NIST is fulfilling its mission, and making continuous improvement in areas where the VCAT has expressed reservations in the last few years, such as safety and cybersecurity. We have every reason to believe this progress will continue.

While the VCAT did not specifically review the NIST core laboratory programs during 2014, the VCAT wants to make the following observation. The basis of the credibility and technical capabilities of NIST is in the excellence of the laboratory programs. It is that excellence that allows NIST to continue its mission and to skillfully take on additional roles in response to evolving national priorities. It is absolutely critical to continue these programs at world class levels. Without these core competencies, NIST will quickly lose its ability to influence and drive the technologies and measurement capability that its commercial stakeholder communities depend on to advance their goals and US competitiveness.

2. Safety

Safety has been a focus and priority of the VCAT for several years and the VCAT is pleased that a culture change toward safety is well underway at NIST. It is moving from the "design-build" phase to one of continual improvement. While NIST has made substantial progress in developing a positive safety culture, continued emphasis on safety is needed to ensure that safety remains a NIST core value. Towards this end, the VCAT continues to:

1. Assess NIST's progress in meeting senior leadership's commitment to making safety an integral core value and vital part of the NIST culture; and
2. Identify strengths and opportunities for improvement in both approach and direction.

In the 2013 report, the VCAT noted NIST's continued emphasis on enhancing the safety culture and offered a set of recommendations to support these efforts, including:

- *NIST should establish a baseline against which to measure the success of its efforts to reduce slips, trips, and falls. NIST should continue to report to the VCAT regularly on progress.*
- *The VCAT recommends that NIST expand the number of common safety issues included in the NIST Shared Standard of Safety Performance.*
- *NIST should implement metrics to demonstrate the success of the NIST Shared Standard program in eliminating common safety issues at NIST.*
- *The VCAT recommends that NIST conduct a safety culture survey to assess its progress in making safety an integral core value and vital part of the NIST culture, and compare the results to those of the safety climate survey completed in June 2011.*

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Response:

NIST has established a baseline against which to measure the success of its efforts to reduce slips, trips, and falls (STFs) based on its incident data for FY 2011-2013. Over that three-year period, STFs accounted for 37% of NIST's OSHA recordable incidents and 37% of its DART cases.

NIST will expand the number of common safety issues included in the NIST Shared Standard of Safety Performance by adding a focus on safe storage practices. NIST will continue to work on addressing and enculturating the initial Shared Standard adopted in early 2014, namely, eliminating STF hazards, using electrical cords safely, and properly labeling chemical containers.

To measure the success of the Shared Standard in eliminating common safety issues, NIST will deploy an enhanced workplace inspection in June 2015. Teams of trained inspectors from each NIST Operating Unit along with inspectors from the Office of Safety, Health, and Environment will conduct semiannual inspections of work areas in which hazardous activities take place and annual inspections of all other work areas. These inspections will provide performance metrics for the Shared Standard.

In 2014, NIST conducted a safety climate survey to measure employee perceptions as they relate to five aspects of NIST's occupational safety and health policy: Management Commitment, Adequacy of Resources, Employee Engagement, Personal Responsibility for One's Own Safety, and Personal Responsibility for the Safety of Others.

The survey included 15 statements taken verbatim from the safety climate assessment conducted in 2011. Composite scores improved on 10 of these 15 statements.

OBSERVATIONS:

The VCAT has focused on safety at NIST since 2012. The Committee continues to see steady improvements in safety performance, including:

- NIST's OSHA-recordable and DART cases have decreased for each of the past four years. These results are attributable to NIST management attention supported by the VCAT's increased emphasis on safety.
- NIST's OSHA total recordable case rates and DART rates compare favorably to those of three representative Department of Energy national laboratories.
- NIST initiated its Shared Standard of Safety Performance in 2014 with a focus on reducing STFs, through safe use of electrical cords, and proper labeling of chemical containers.
- NIST reduced the number of STFs resulting in more serious injuries by 50% in FY 2014 compared to the STF baseline.
- NIST conducted a safety climate survey. Over 1,900 employees participated, for a participation rate of 59.8%. This was 14 percentage points higher than the assessment conducted in 2011.
- Approximately 90% of employees indicated that they generally believe all levels of NIST management clearly consider safety of employees to be of great importance, but there are opportunities for improvement in the areas listed in sidebar.

NIST 2014 Safety Survey: Opportunities for Improvement

- Improve communication of safety rights to employees.
- Provide guidance on addressing unsafe conditions and practices.
- Implement improved incident reporting processes and mechanisms for sharing lessons learned.
- Improve the quality of safety training.
- Incorporate discussions of safety culture issues into management observations.
- Re-emphasize the importance of employees receiving safety performance feedback.

RECOMMENDATION:

- Continue to report regularly to the VCAT on NIST’s safety improvement efforts, including the actions identified in the safety climate survey.

3. NIST Cryptographic Standards Program

Originally established in 2013, the VCAT Subcommittee on Cybersecurity was tasked with making recommendations on NIST’s ability to support the nation’s cybersecurity needs. Initial comments and recommendations from the Subcommittee were submitted in the 2014 Annual VCAT Report.

3a. NIST Committee of Visitors

In February 2014, NIST asked the VCAT, under the Subcommittee on Cybersecurity, to form a Committee of Visitors (COV), essentially a panel of experts in cybersecurity, in order to review and provide feedback to the VCAT on NIST’s current processes for developing cryptographic standards and guidelines, examine NIST’s current body of cryptographic guidance to determine if it was developed in accordance with NIST’s commitment to inclusive and transparent processes, and identify any needed corrective actions to this current body of guidance.

Based on the individual assessments of the COV members, the VCAT published a [final report](#) to NIST on July 14, 2014 with the set of recommendations outlined below.

Openness and Transparency

It is of paramount importance that NIST’s process for developing cryptographic standards is open and transparent and has the trust and support of the cryptographic community. This includes improving the discipline required in carefully and openly documenting such developments.

NIST should also develop and implement a plan to further increase the involvement of the cryptographic community, including academia and industry, in the standards-development process.

The Subcommittee strongly encourages standard development through open competitions, where appropriate.

Independent Strength and Capabilities

In order to be better positioned to exercise independent judgment on critical technical questions regarding cryptographic and security standards, NIST should strive to increase the number of technical staff with such expertise.

The Subcommittee also strongly suggests NIST explores, in addition to the current avenues, expanding its programs to engage academia and outside experts to aid in the review of specific technical topics.

Original Charge to the VCAT and the COV:

As a critical component of this review, Dr. Patrick Gallagher has charged the NIST Visiting Committee on Advanced Technology (VCAT) to form a Committee of Visitors (CoV) to serve as technical experts to assess NIST cryptographic standards and guidelines development process and if necessary provide findings on how it can be improved.

To assist the VCAT in this review, the VCAT has charged the CoV to provide feedback on the ability of NIST to continue to assure the cryptographic community, users, and especially international partners of the technical soundness of NIST cryptographic reference materials and the validity of the process to update and amend these reference materials as needed. Specifically, the CoV will:

1. *Review NIST’s current cryptographic standards and guidelines development process and provide feedback on the principles that should drive these efforts, the processes for effectively engaging the cryptographic community and communicating with stakeholders, and NIST ability to fulfill its commitment to technical excellence.*
2. *Assess NIST cryptographic materials, noting when they adhere to or diverge from those principles and processes.*

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Clarification of the Relationship with NSA

NIST may seek the advice of the NSA on cryptographic matters but it must be in a position to assess it and reject it when warranted. This may be accomplished by NIST itself or by engaging the cryptographic community during the development and review of any particular standard.

The Subcommittee recommends that NIST senior management reviews the current requirement for interaction with the NSA and requests changes where it hinders its ability to independently develop the best cryptographic standards to serve not only the United States Government but the broader community.

Technical and other Issues

The VCAT Subcommittee on Cybersecurity notes that the members of the CoV made a number of very specific technical recommendations. The Subcommittee recommends that NIST work openly with the cryptographic community to determine how best to address such recommendations.

The CoV reports also include a number of recommendations for improving the processes used in the development of cryptographic material. The Subcommittee recommends that NIST takes into account all such recommendations as it develops its guidelines and development process documents.

3b. NIST Actions in Response to the Recommendations

During the October 2014 meeting, NIST provided the VCAT with an update on the activities to date and future plans related to the recommendations outlined above.

In the area of Openness and Transparency, NIST has drafted an Interagency Report entitled, *NIST Cryptographic Standards and Guidelines Development Process* and has enlisted public comments to be considered in the final publication. NIST has made available all materials provided to the COV by posting the content on the VCAT website. NIST has held open discussions with multiple stakeholders for awareness and input.

In the area of Independent Strength/Capabilities, NIST brought on additional staff and guest researchers as well as created a Washington DC-Area Cryptographic Group. NIST has a major focus on strengthening the pipeline of staff and engagements to support this research area, and the \$6M in new FY 2015 funding will bring on more cryptography research staff and continue efforts to build a world-class program in this area that is not dependent on NSA for research capability support.

With regards to clarifying the relationship with NSA, NIST plans to acknowledge all NSA contributions to NIST issued guidance. The [NIST / NSA Memorandum of Understanding \(MOU\)](#) is publicly posted and the terms of the MOU are being reevaluated. In addition, initial introductions and discussions with new Director of the National Security Agency and the Acting NIST Director were held.

Actions in the area of Technical Work, Development and Processes include removal of the algorithm in question, Dual Elliptic Curve Deterministic Random Bit Generator, from draft guidance on random number generators. NIST has also initiated internal reviews of the NIST cryptographic reference materials and is participating with the Internet Engineering Task Force (IETF) Cryptographic Forum Research Group.

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OBSERVATIONS:

- The VCAT is pleased with NIST initial response and planning activities based upon the recommendations captured in the VCAT report “NIST Cryptographic Standards and Guidelines Development Process” issued in July 2014. In particular,
 - Issuing a revised version of draft publication NISTIR 7977 which captures the changes adopted to address the recommendations
 - The increase by an additional \$6M in FY15 budget directed to cryptographic and computer security work
- The Cybersecurity Framework for Critical Infrastructure published last year continues to receive broad support and initial implementations are under way. The VCAT is pleased that NIST is committed to taking an iterative, collaborative approach working with stakeholders, and promoting the Framework broadly.

RECOMMENDATIONS:

- The VCAT recommends and expects that NIST will continue to review and improve its processes for the development of cryptographic standards following the recommendations it received in 2014 from the Committee of Visitors, and remain independent, open, and transparent.
- The VCAT recommends that NIST continues to promote and raise awareness of the Cybersecurity Framework for Critical Infrastructure, including regional workshops and provide implementation assistance to stakeholders.

4. NIST Role in Disaster Resilience

Natural and man-made disasters cause an estimated \$57B in average annual costs, with large single events resulting in losses of \$100B or more. Recent events, such as the World Trade Center disaster, Hurricane Katrina, and Superstorm Sandy, have highlighted a need to consider the functionality and interdependencies of buildings and infrastructure systems and the role they play in restoring the fabric of the community following a hazard event. The current approach of response and rebuilding is impractical and inefficient for dealing with natural disasters. A resilience based-approach will provide the framework and guidance needed to enable communities to resist, respond to, and recover from hazard events more rapidly and at lower costs. In support of this, the President’s Climate Action Plan calls for the development of a “comprehensive, community-based resilience framework and provide guidelines for consistently safe buildings and infrastructure – products that can inform the development of private-sector standards and codes.” NIST was identified as the lead in this effort.

The VCAT was asked by the NIST Director to consider the balance between the increasing and extensive expectations placed on NIST in disaster resilience and NIST’s capacity in this area.

4a. Disaster Resilience Activities at NIST

Over the years, NIST has developed a number of core competencies relating to disaster resilience, such as fire modeling and prediction at the building and community scale, hazard analysis, and wind/storm surge load characterization. NIST has several statutory authorities covering activities and responsibilities related to the National Earthquake Hazard Reduction Program, the National Construction Safety Team Act, and the National Windstorm Impact Reduction Program. These specific responsibilities and authorities are spelled out in a number of pieces of legislation, including the NCST Act, inspired by the events of 9/11 and modeled after the National

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Transportation Safety Board. NIST has conducted three investigations under this authority – World Trade Center (including a report on the Towers and on WTC7), a 2003 fire in West Warwick, Rhode Island, and the Joplin Tornado. NIST also has a legislated role in NEHRP, where it has lead agency authority to coordinate an interagency group.

NIST work in this area has resulted in a number of disaster studies on earthquakes, hurricanes, tornadoes, fires, and building failures, decisions criteria for evaluating the need for an investigation, NEHRP strategic plan outlining priorities and a roadmap for earthquake-resilient lifelines.

4b. Responding to an Expanding Role in Disaster Resilience

To most effectively build on NIST competencies and respond to expanding authorities, NIST has developed a multi-faceted approach to a disaster resilience program and the development of a community resilience framework. This includes:

- ❖ Disaster Resilience Workshops: NIST will convene a series of workshops engaging a broad network of stakeholders to help develop the Disaster Resilience Framework, with a focus on the role that buildings and infrastructure lifelines play in ensuring community resilience.
- ❖ Disaster Resilience Framework: NIST will develop a Disaster Resilience Framework to establish the overall performance goals; assess existing standards, codes, and practices; and identify gaps that must be addressed in order to bolster community resilience.
- ❖ Disaster Resilience Standards Panel (DRSP): The DRSP will be a self-governing body, initially supported by NIST, which will meet regularly to develop Model Resilience Guidelines for critical buildings and infrastructure lifelines essential to community resilience. The DRSP also will continue development of the Disaster Resilience Framework.
- ❖ Model Resilience Guidelines: The Model Resilience Guidelines will promote best practices, methods and innovative solutions to help communities develop their own disaster resilience plan for critical buildings and infrastructure systems.
- ❖ Community Resilience Center of Excellence: The Community Resilience Center of Excellence will focus on tools to support community disaster resilience, including the development of integrated, systems-based computational models to assess community infrastructure resilience and guide community-level resilience investment decisions. The proposed center also will develop a data management infrastructure, as well as tools and best practices to improve the collection of disaster and resilience data.

This approach combined with recent organizational changes creating a Community Resilience Group within NIST's Engineering Laboratory is allowing NIST to leverage resources, partnerships, and collaborations to address the statutory authorities and Presidential priorities in this area.

OBSERVATIONS:

- NIST is uniquely qualified to address the expanded authorities in the area of disaster resilience.
- The NIST plan is multifaceted and provides support in ways that can be targeted to individual community needs.

RECOMMENDATIONS:

- The VCAT is pleased with the directions that NIST is taking in addressing disaster resilience and encourages NIST to continue with their plans and to champion the framework.

5. NIST Role in Advanced Communications

Increasing demand for mobile communications and data services has led to numerous activities to both obtain more radio spectrum for mobile use, and to use spectrum more efficiently, thus avoiding a “spectrum crunch” that would limit mobile data rates and capacities. Several Federal and Congressional actions are a driving impetus for NIST’s focus in this area. These include: 1) the FCC’s 2010 National Broadband Plan for reallocating or sharing 500 MHz of spectrum from federal to commercial use; 2) a 2012 PCAST report urging that underutilized spectrum be shared through development of dynamic sharing methods; 3) the 2012 Middle Class Tax Relief Act (P.L. 112-96) mandated the auction of several spectrum bands from government to commercial use, increased the use of unlicensed spectrum, and authorized a nationwide broadband public safety first responder’s network (“FirstNet”) funded by auction proceeds. In response, NIST and the National Telecommunications and Information Administration (NTIA) agreed in 2014 to form a collaborative “Center for Advanced Communications” (CAC) through which the two agencies could combine their complementary expertise to enhance spectrum use through the improvement and application of measurements. In 2014, the VCAT was briefed on NIST’s role and efforts in this area.

5a. Advanced Communications Activities at NIST

In March of 2014, the NIST Director established a new operating unit at NIST, the Communications Technology Laboratory (CTL), to conduct leading edge R&D on both the metrology and understanding of phenomena and systems relevant to advanced communications. More specifically, CTL is to direct NIST’s contributions to the CAC through research targeted at supporting testing, including the development of precision instrumentation, validated test-protocols, models, and simulation tools necessary to support the advancement of communications technologies.

CTL’s organization includes NIST’s Public Safety Communications Research (PSCR) program that provides research, development, standards, testing, and evaluation to foster nationwide first responder communications interoperability. PSCR has taken a leadership role in transforming first responder requirements into equipment standards, and provides measurements to validate conformance to key standards. With the creation of FirstNet, PSCR began support of broadband LTE technology, and has successfully promoted adoption of key public safety requirements into LTE standards. PSCR operates an extensive LTE demonstration network comprised of numerous systems, supported by collaborators through over 60 Cooperative Research and Development Agreements (CRADAs).

Additional communications-related activities from other NIST operating units were moved into CTL to provide foundational measurement expertise in radio frequency (RF) component and test equipment characterization, antenna metrology, electromagnetic compatibility, and traceability of complex waveforms beyond 100 GHz. In addition, the realignment transferred a wireless networking group to CTL that brings expertise in wireless network simulation and modeling, propagation modeling, spectrum sensing and monitoring, and spectrum sharing technologies. Integration of these new programs is underway, and CTL is refocusing efforts from general physical measurement science toward addressing priority measurement challenges in communications and spectrum sharing.

5b. Importance of Partnerships and Collaboration

CTL’s success depends on a number of partnerships and collaborations. Of overriding importance is the CAC collaboration between CTL and NTIA’s Institute for Telecommunication Sciences (ITS). These two labs bring complementary expertise to spectrum sharing problems, and tangible benefits are gained from close cooperation.

A key element of the CAC collaboration is the National Advanced Spectrum and Communications Test Network (NASCTN). The goal of NASCTN is to facilitate and coordinate spectrum sharing and engineering capabilities among government, academic, and commercial entities to enable effective measurements that productively inform sharing and reallocation decisions. Initially, NASCTN is a DOD and DOC partnership, but the intent is to include

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other agencies that are seeking to share spectrum as outlined by the FFC rules and legislative mandates. DOD is a strong proponent of the NASCTN process, and sees a trusted measurement framework as the key to moving spectrum sharing or re-allocation within DOD-occupied bands. The current process of ad-hoc measurements provides results that are often inconclusive because of disagreements in measurement methods, modeling, data analysis, or the inability to share data due to security concerns. CAC can provide neutral third-party guidance and validation of measurement campaigns that may increase confidence in results and challenge orthodoxy that may not be grounded in fact. Success will require considerable outreach by CTL/CAC to ensure that affected parties are apprised of studies and allowed to have concerns addressed during test plan development, so that post-test debates are limited.

In addition, PSCR has developed a robust stakeholder group, and collaborated to successfully define practitioner needs that it can subsequently translate into standards. The partnership with FirstNet is equally important, and PSCR is well positioned to greatly contribute to FirstNet's success.

5c. Optimum Balance for NIST's Advanced Communications Activities

CTL has developed a capability planning document as part of NIST's strategic planning process. This plan focuses CTL's resources in four areas: 1) creation and implementation of NASCTN as a means of facilitating measurements to improve spectrum sharing, while also developing internal measurement techniques and processes that support sharing and coexistence; 2) increased effort in public safety communications measurements and standards, including R&D work to increase the capability of FirstNet's anticipated broadband first responder network; 3) advanced metrology R&D to support next generation ("5G") wireless communications; and 4) advanced metrology R&D to support next generation optical communications. In addition, CTL will continue to support the legacy RF, waveform, and antenna measurement services, while improving these to meet communication needs outlined by the four focus areas.

Currently, CTL has resources to fully fund items related to NASCTN (including strengthening spectrum sharing, coexistence, and channel propagation and modeling expertise) and public safety (priorities 1 and 2). In addition, CTL plans to seed-fund select programs in next-generation 5G wireless technologies, but will not be committing resources toward optical communications at this time. Within 5G research, the initial programs will focus on measurements to support massive-MIMO (multiple-input multiple-output) antenna, millimeter wave (24 to 100 GHz) technology, and ultra-dense heterogeneous networks; these are important potential 5G technologies that also present demanding measurement challenges, and are thus appropriate for NIST engagement.

The pace of technology development in next-generation wireless is accelerating. Significant value is derived from the technologies that comprise communication standards, and several companies are making aggressive investments in potential technologies. Furthermore, Europe and Asia are leading 5G R&D activities with substantial government funding, and with the stated intention to influence standards: The EU has several programs funded in excess of €1.4B, and the Republic of Korea has created a "5G forum" with \$1.5B government funding through 2020. Notably, the EU and Korea have signed an agreement to cooperatively define global 5G standards. Asian countries in particular are targeting 5G commercialization in 2020. China has established an "IMT2020 Promotion Group" to coordinate efforts from three ministries, and Japan has created a "2020 and Beyond Ad Hoc" effort.

OBSERVATIONS:

- The VCAT is very pleased with NIST's current plans for its involvement in the area of Advanced Communications. The plan focuses on NIST areas of strength, such as measurement science, stresses collaborations such as that with the NTIA to tackle spectrum sharing, and that with FirstNet, which positions NIST to be the de facto R&D lab for the Public Safety Network.

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- The VCAT is also pleased with the progress in the establishment of the labs and centers that will carry out its missions in the advanced communications area.
- The recent FCC auction of radio-frequency spectrum rights will provide a one-time \$300M investment to NIST to support an advanced communications system for the nation's first responders. After 2022, there will be a need for continued investment to sustain support for these efforts.

RECOMMENDATION:

- NIST can play a significant role in the successful development of a robust and forward looking Public Safety Network. The VCAT recommends that NIST continue its commitment to be the advocate for public safety in the development of current wireless standards and future 5G standards. This can be accomplished by strengthening its internal capabilities and by forging international alliances among the public safety communities.

6. Advanced Manufacturing

During 2014, the VCAT was updated on NIST's continued focus on advanced manufacturing. From the NIST laboratories addressing measurement challenges to NIST user facilities supporting innovation in materials science and nanotechnology fabrication to the Hollings Manufacturing Extension Partnership (MEP) working directly with manufacturers helping solve technology and production issues, NIST is committed to supporting U.S. manufacturing.

In 2014, NIST's new Advanced Manufacturing Technology Consortia (AMTech) awarded 19 advanced manufacturing technology planning grants totaling \$9M. The funded projects will identify and rank research and development goals, define workforce needs, and initiate other steps toward speeding technology development and transfer and improving manufacturing capabilities. Project collaborations span a wide variety of industries and technologies, from flexible-electronics manufacturing to biomanufacturing and from pulp-and-paper manufacturing to forming and joining technologies.

In addition, the Advanced Manufacturing National Program Office (AMNPO) continues to serve as a central point of contact for federal programs in advanced manufacturing and the coordination lead for the National Network of Manufacturing Innovation (NNMI) program. This role has become even more important with the passage of the Consolidated and Further Continuing Appropriations Act of 2015, which also included the Revitalize American Manufacturing and Innovation Act of 2014 (RAMI). This legislation authorizes NIST to support the complete network of existing pilot institutes and all new institutes created under this Act. The Act also requires NIST to run competitions for new institutes on topics proposed by industry, with evaluations by external panels, a significantly different process than the topic-specific competitions run by the Departments of Defense and Energy. While RAMI provides important authorization language for NIST it does not provide any funding. However, the FY2016 President's budget proposes \$150M for NIST to hold competitions for Commerce-led Institute.

OBSERVATION:

- The VCAT is pleased with the continued focus on advanced manufacturing and supports expanding the NNMI network with a Commerce-led institute.

RECOMMENDATION:

- The VCAT encourages NIST to use the industry-generated ideas collected by the AMNPO to begin the process of implementing the creation and operation of new institutes.

7. NIST Budget and Planning

7a. NIST Three-Year Programmatic Plan 2016-2018

The Committee has read and reviewed the draft NIST three-year programmatic plan as of February 2015 and believes that it accurately portrays the near-term path of activity and development at NIST. The Committee appreciates NIST management's continued focus on developing longer-term strategic plans outlining the agency needs and challenges that are evident in this programmatic plan. The VCAT supports NIST's continued focus on core measurement needs related to precision measurement, complex systems, and data, which will enable NIST to address emerging measurement and technology needs across multiple sectors.

7b. NIST Budget (Dollars in Millions)

	FY 2014 Enacted	FY 2015 Enacted	FY 2016 Request
Scientific and Technical Research and Services (STRS)	\$651.0	\$675.5	\$754.7
Laboratory Programs	578.0	591.3	661.6
Corporate Services	17.3	17.3	16.9
Stds Coord & Special Pgms	55.7	66.9	76.2
Industrial Technology Services (ITS)	\$143.0	\$138.1	\$306.0
Advanced Mfg Tech Consortia	15.0	8.1	15.0
Hollings Mfg Ext Partnership	128.0	130.0	141.0
Nat'l Network for Mfg Innovation ¹	0.0	0.0	150.0
Construction of Research Facilities (CRF)	\$56.0	\$50.3	\$59.0
Construc & Major Renovations	11.8	0.0	0.0
Saf, Cap, Maint & Maj Repairs	44.2	50.3	59.0
Total, NIST Discretionary	850.0	863.9	1,119.7

¹National Network for Manufacturing Innovation is a newly proposed program in FY 2016.

7c. FY 2015 Appropriations and FY 2016 Request

The FY 2015 Omnibus appropriations grew the NIST budget by a total of \$13.9M over FY2014 enacted numbers. The real growth came in the laboratory budget where NIST received an additional \$24.5M to strengthen cybersecurity R&D, improve federal technology transfer, strengthen forensic science and Green House Gas measurement technologies, cyberphysical systems, and support for additional NIST R&D in biomanufacturing and precision metrology. The VCAT is strongly supportive of this budget growth, especially as it provides much needed funding that will help address some of the recommendations of the VCAT and the Cybersecurity Committee of Visitors. Unfortunately, the FY2015 funding saw cuts to NIST's extramural programs supporting manufacturing, and NIST's funding for construction and renovation.

VISITING COMMITTEE ON ADVANCED TECHNOLOGY
National Institute of Standards and Technology

OBSERVATION:

- The VCAT is pleased with the budget increases NIST has received and feels the FY2016 proposed budget is sufficient to fund NIST core programs and new initiatives.

RECOMMENDATION:

- The VCAT wants to emphasize the importance of continued investment in NIST's physical infrastructure. Maintaining a world class research facility requires a constant level of investment to support the maintenance and the upgrade of the laboratory facilities. Continued suboptimal investment in this area will negatively impact NIST's long-term ability to meet its mission.