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Report to the Subcommittee on Research and Technology, Committee on Science, Space, and Technology, House of Representatives

July 2018

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Additional Review and Coordination Could Help Meet Measurement Service Needs and Strengthen Standards Activities

GAO-18-445

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GAO Highlights

Highlights of GAO-18-445, a report to the Subcommittee on Research and Technology, Committee on Science, Space, and Technology, House of Representatives

Why GAO Did This Study

The U.S. Department of Commerce's NIST provides measurement services and supports standards that promote U.S. competitiveness. For example, NIST provides calibrations for manufacturing equipment and reference materials used in testing. NIST also supports private sector organizations in developing standards to help ensure product performance, among other things, such as Wi-Fi. In recent years, NIST has sought to improve the delivery of its services and documentary standards activities.

GAO was asked to review NIST measurement services and standards-support activities. This report examines (1) the challenges NIST faces in providing measurement services and supporting documentary standards development, and (2) the extent to which NIST has taken steps to address these challenges and how those steps align with federal guidance and policy. GAO analyzed testimony, reports, laws, and policies; conducted focus groups with academics and industry representatives; and interviewed various stakeholders.

What GAO Recommends

GAO is making seven recommendations, including that NIST comprehensively review measurement services and documentary-standards activities, and work with other agencies to take steps to strengthen interagency coordination. The Department of Commerce agreed with six recommendations and disagreed with one, citing risks to the private-sector-led U.S. standards system. GAO clarified its recommendation and continues to believe this action is needed, as discussed in the report.

View GAO-18-445. For more information, contact John Neumann at (202) 512-3841 or neumannj@gao.gov.

What GAO Found

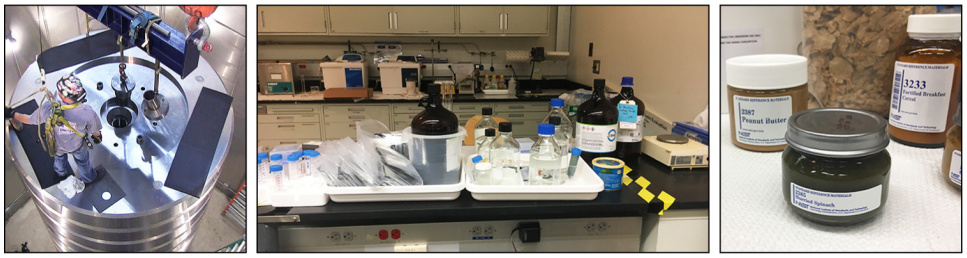
The National Institute of Standards and Technology (NIST) faces challenges in providing measurement services and supporting private sector development of specifications for products' designs or performance—referred to as "documentary standards." Based on reviews of relevant testimony, reports, and other documents; interviews with stakeholders; and focus groups with academics and industry representatives, GAO identified challenges including:

- Identifying and prioritizing what measurement services, such as calibrating large force-measurement tools used by aerospace manufacturers, or what documentary standards activities, such as serving as a technical advisor on fire safety standards, are most needed by U.S. industry, and
- Coordinating with other federal agencies on standards development issues.

NIST has taken steps to address these challenges, including industry outreach and reviews of measurement services and standards activities. However, some efforts do not fully align with federal guidance or NIST policy. For example, NIST's measurement-services and standards-activity reviews have not included a comprehensive examination of how these services and standards activities align with stakeholder needs. Federal internal control standards call for managers to use quality information to determine if the agency is meeting its objectives. Comprehensively reviewing NIST's measurement services and documentary-standards activities would provide NIST with greater confidence that its services and activities align with stakeholders' needs.

GAO also found that NIST coordinates with other agencies on standards development and related activities, but that some efforts do not fully align with specific leading practices GAO has previously identified for enhancing and sustaining interagency collaboration. For example, NIST and other agencies coordinate on standards activities through a NIST-chaired interagency committee. However, GAO found that the committee has not updated its charter since 2000—contrary to leading practices to update and monitor collaborative agreements. GAO also found that NIST has not worked with other committee members to fully clarify agencies' roles and responsibilities. Without ensuring that member agencies' roles and responsibilities are current and fully clarified, NIST and other agencies may miss opportunities to strengthen coordination.

Examples of National Institute of Standards and Technology (NIST) Measurement Services



A worker stands atop NIST's million-pound deadweight machine (left); a laboratory bench at NIST (center); and containers of food-related standard reference materials produced by NIST.

Sources: NIST (left photo); GAO (center and right photos). | GAO-18-445

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Abbreviations

1979 act	Trade Agreements Act of 1979
ANSI	American National Standards Institute
Commerce	Department of Commerce
EOP	Executive Office of the President
ICSP	Interagency Committee on Standards Policy
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
National Academies	National Academies of Sciences, Engineering, and Medicine
NIST	National Institute of Standards and Technology
NTTAA	National Technology Transfer and Advancement Act of 1995
OMB	Office of Management and Budget
SDO	standards development organization
USTR	Office of the United States Trade Representative
VCAT	Visiting Committee on Advanced Technology

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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July 26, 2018

The Honorable Barbara Comstock
Chair
The Honorable Daniel Lipinski
Ranking Member
Subcommittee on Research and Technology
Committee on Science, Space, and Technology
House of Representatives

Commercial transactions rely on a buyer and seller having a shared understanding about certain aspects of the goods being exchanged, such as their size or other technical specifications. For example, motorists expect that the volume of fuel dispensed from a gasoline pump accurately matches the volume for which they are charged. Standards help define the technical aspects or capabilities of materials, devices, machines, and other products to ensure their performance and interoperability. Standards include units of measurement, such as the gallon, and standards that can describe the performance or design of a product, process, or test—referred to as "documentary standards." Wi-Fi, for example, is a set of documentary standards that define a particular type of wireless communication network. Devices that follow the same Wi-Fi standard will be compatible regardless of manufacturer, thus providing consumers with more choices among similar products.

The National Institute of Standards and Technology (NIST) is an agency within the Department of Commerce (Commerce) that, since 1901, has provided measurement services and tools and has helped develop and maintain key measurement and documentary standards to help U.S. industry compete.[1] Specifically, NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve quality of life. NIST's measurement services include, among other things, calibrating equipment, such as industrial thermometers, to ensure their accuracy and precision. NIST also sells standard reference materials that researchers and manufacturers can use to test the purity, strength, or other attributes of their products. NIST's measurement services help businesses ensure that their products meet

[1]Prior to 1988, the agency was named the National Bureau of Standards.

relevant standards and give consumers confidence in the products they purchase. Similarly, NIST supports the development of measurement and documentary standards in many ways.[2] NIST plays a leading role in developing some standards, such as standards that support many basic units of measurement and certain documentary standards on the operation of federal information technology systems. However, the United States has a voluntary, consensus-based standards system, whereby most documentary standards are developed collaboratively by producers and users through private-sector standards development organizations (SDO). Consequently, NIST staff may participate in SDO-led standards development activities by, for example, serving as technical advisors.

Because advances in science and technology continue to drive growth in many commercial sectors, NIST's measurement services and support for developing documentary standards can directly affect innovation and the nation's economy. To fulfill its mission, NIST relies on the expertise and research of its staff across a number of laboratories. NIST reorganized its laboratory structure in 2010, in part, to improve the delivery of the agency's services. Under the previous laboratory structure, mission-based activities were often spread across numerous laboratories. In testimony before the House Committee on Science and Technology's Subcommittee on Technology and Innovation in March 2010, the Director of NIST stated that restructuring the agency's laboratories would make NIST more effective in delivering its services to customers.[3] Since that time, NIST has taken additional steps designed to improve its measurement services and documentary standards activities.

You asked us to examine NIST's measurement services and standards development activities. This report examines (1) the challenges NIST faces in providing measurement services and supporting documentary-standards development; and (2) the extent to which NIST has taken steps to address any challenges and how those steps align with relevant federal guidance and policy.

[2]For purposes of this report and to avoid repetition, we use the term standards primarily to refer to documentary standards created by standards development organizations (SDO). We use the term measurement standards when referring to NIST's efforts relating to defining units of measurement.

[3]*NIST Structure and Authorities, Its Role in Standards, and Federal Agency Coordination on Technical Standards, Before the S. Comm. on Technology and Innovation*, 111th Cong. 7-14, (2010) (statement of Hon. Patrick D. Gallagher, Director, National Institute of Standards and Technology).

To identify any challenges NIST may face in providing measurement services and supporting documentary-standards development, we began by performing a literature review, including reports on NIST from the National Academies of Sciences, Engineering, and Medicine (National Academies); NIST's Visiting Committee on Advanced Technology (VCAT); and other sources.[4] We supplemented our review of the challenges identified in these sources by analyzing the responses of participants in focus groups we organized of NIST stakeholders comprised of: (1) researchers and (2) representatives working with industry, including commercial entities and state metrology laboratories.

We selected researchers to participate in our focus groups from university scientists in engineering and the physical and biological sciences. We selected industry participants for the focus groups to reflect a range of industrial sectors, including (1) sectors that contribute the most to U.S. gross domestic product, and (2) sectors that Commerce has identified as representing U.S. export opportunities. We also included representatives from the National Conference on Weights and Measures, a nonprofit association of state and local weights and measures officials, federal agencies, manufacturers, retailers, and consumers that addresses consumer measurement needs. We conducted 3 focus groups for representatives from industry and 2 focus groups for researchers. Each focus group included from 5 to 8 individuals. In total, our focus groups included 31 stakeholders.[5]

We also collected information on the challenges that NIST faces during 36 interviews, including 17 interviews with current and former NIST officials, 10 interviews with officials from other federal agencies, and 9 interviews with representatives from SDOs and other stakeholders. The 10 interviews we conducted with other federal agency officials included 8 agency standards executives—senior level officials with knowledge of,

[4]According to NIST officials, under a contract with NIST, the National Academies of Sciences, Engineering, and Medicine's Laboratory Assessment Board has regularly reviewed individual NIST laboratories and the effectiveness of their activities since 1959. VCAT is a federal advisory committee that reviews and makes recommendations regarding NIST's general policy and the agency's organization, budget, and programs, within the framework of applicable national policies as set forth by the President and Congress. As a part of that role, VCAT provides ongoing advice to NIST on measurement services and documentary-standards development activities.

[5]See appendix I for additional information on our focus groups and the methodology we used to select focus group participants. Appendix I also provides greater detail on other aspects of our scope and methodology.

and experience in, standards-related issues at their agencies and who are responsible for coordinating their agency's participation in SDOs, among other responsibilities.[6]

To evaluate the steps NIST has taken to address challenges in providing measurement services and in supporting documentary-standards development, we drew upon our focus groups, interviews with NIST staff, and reviews of NIST documentation that described the agency's measurement services and standards development activities, such as agency policies, orders, and publications. We also conducted a review of existing literature as well as relevant laws, NIST policies, and other agency guidance documents. We compared the steps NIST has taken to address the challenges it faces in providing measurement services and supporting standards development to these policies and guidance. We also assessed how well NIST's efforts align with *Standards for Internal Control in the Federal Government* and selected leading practices for sustaining and enhancing interagency collaboration that we identified in previous work.[7]

We conducted this performance audit from July 2016 to July 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[6]The qualifications and requirements for agency standards executives are described in more detail in Office of Management and Budget, *Circular A-119: Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities* (Washington, D.C.: Jan. 27, 2016). The agencies whose standards executives or other officials we interviewed included the Departments of Defense, Energy, and Homeland Security, and Health and Human Services, as well as the Consumer Product Safety Commission, Environmental Protection Agency, General Services Administration, and Office of the U.S. Trade Representative.

[7]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: Sept. 2014); GAO, *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms,* GAO-12-1022 (Washington, D.C.: Sept. 27, 2012); and GAO, *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, GAO-06-15, (Washington, D.C.: Oct. 21, 2005). Internal controls comprise the plans, methods, policies, and procedures used to fulfill the mission, strategic plan, goals, and objectives of the agency. We selected collaboration leading practices related to NIST's leadership of the Interagency Committee on Standards Policy. Additional information on these practices is in appendix I.

Background

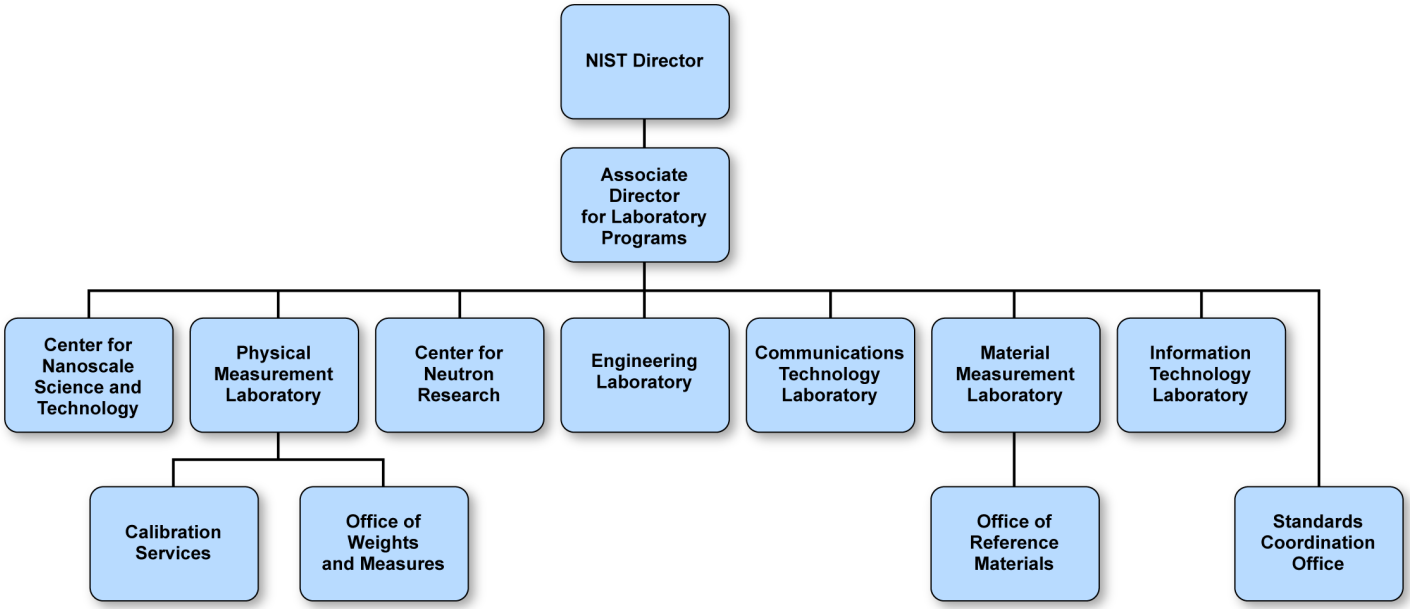
NIST carries out its measurement services and documentary-standards development activities across several agency laboratories. NIST's standards activities include participation in private-sector standards development organizations that conduct most standards development in the United States, and federal law and guidance provide direction to agencies when they participate in this process.

NIST's Management of Measurement Services and Documentary Standards Activities

NIST's work underlies much of our nation's business and public infrastructure, from helping to ensure the quality of air and water to helping to ensure the security of online financial transactions. This work includes providing measurement services, such as calibrations of equipment and reference materials used to ensure the accuracy and reliability of a wide range of scientific and industrial devices, and support for the development of documentary standards by the private sector. As of July 2017, NIST employed approximately 3,500 federal personnel and hosted 4,000 associates, who include guest researchers and collaborators, student interns, facility users, and contractors at its locations in Gaithersburg, MD and Boulder, CO.

Under its Associate Director for Laboratory Programs, NIST's activities span seven laboratory programs that cover a wide range of subject matter, such as bioscience and health, energy, manufacturing, and public safety and security (see figure 1). The seven laboratories are divided into divisions and groups of scientists and engineers who perform research in a certain field or discipline, and may also provide measurement services or participate in standards activities. In addition, NIST has three offices that primarily deal with measurement services: (1) the Office of Reference Materials within the Material Measurement Laboratory; (2) Calibrations Services within the Physical Measurement Laboratory; and (3) the Office of Weights and Measures also within the Physical Measurement Laboratory. Further, the Standards Coordination Office, which is also under the Associate Director for Laboratory Programs, conducts standards-related activities and provides guidance to NIST staff on participation in documentary standards activities.

Figure 1: Laboratories and Offices of the National Institute of Standards and Technology (NIST) with Roles in Measurement Services or Documentary Standards



Source: GAO analysis of NIST documents. | GAO-18-445

In 2010, NIST reorganized its laboratory structure, in part to improve the agency's provision of measurement services. Under the new structure, the Physical Measurement Laboratory includes staff that handles most of the agency's measurement standards and calibrations. The Material Measurement Laboratory includes staff supporting materials science and produces most of the agency's standard reference materials. According to the NIST Director at the time of the reorganization, managing related research and measurement services together would allow the agency to improve its services.[8]

NIST's measurement services encompass calibrations, standard reference materials, and standard reference data, among others. NIST provides calibration services for about 700 different types of devices and has over 1,200 different types of reference materials available (see figure

[8]*NIST Structure and Authorities, Its Role in Standards, and Federal Agency Coordination on Technical Standards, Before the S. Comm. on Technology and Innovation*, 111th Cong. 7-14, (2010) (statement of Hon. Patrick D. Gallagher, Director, National Institute of Standards and Technology).

2). For example, NIST performs calibrations on many different types of thermometers for both scientific and industrial uses. For customers that have unique calibration needs, NIST can perform special tests tailored to their specific circumstances. NIST also performs detailed analysis of certain materials to precisely characterize their properties and makeup and provides these reference materials for use by others. For example, NIST produces a number of food-related reference materials that allow companies to accurately determine the nutritional content of their products.

Figure 2: Examples of the National Institute of Standards and Technology's (NIST) Calibration Equipment and Standard Reference Materials

National Institute of Standards and Technology's (NIST) trace explosives reference material (left) is used to test the accuracy and reliability of explosive detection machines. The million-pound deadweight system (right) in NIST's Gaithersburg, MD, location is used, among other purposes, to calibrate sensors used to test aircraft wings to ensure they can withstand stresses that occur during flight.

Sources: J. Lee and Irvine/NIST. | GAO-18-445

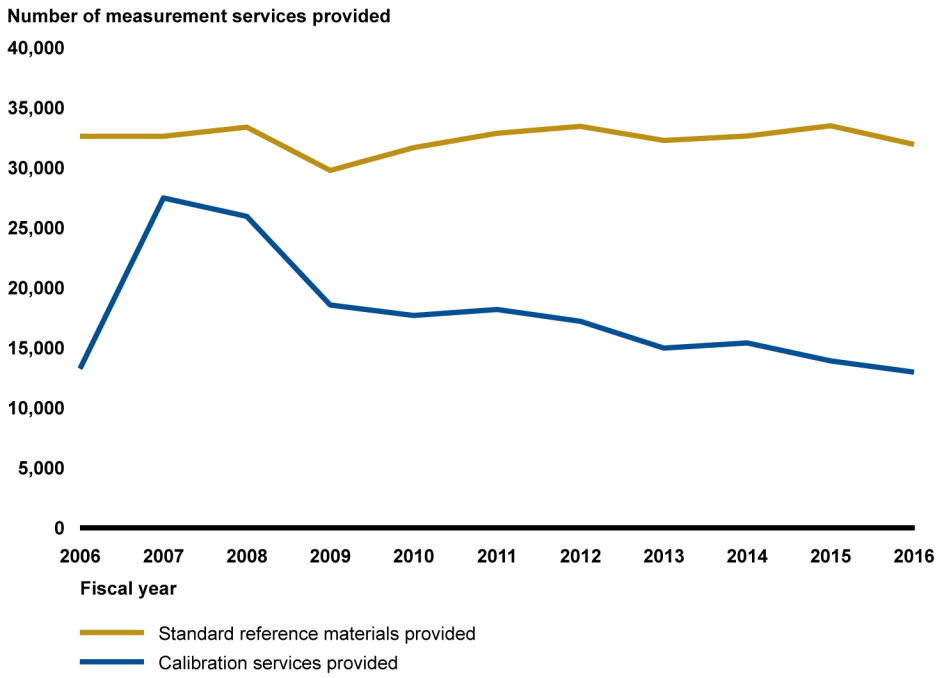
NIST has established a formal quality-control system covering the calibrations, special tests, and standard reference materials provided by the agency. The NIST quality system is intended to provide customers with confidence in the quality of NIST's measurement services and create an environment of continual improvement for NIST management and staff. The quality system is described in policies and procedures governing the agency's measurement services. Specifically, the *NIST Quality Manual for Measurement Services*, NIST-QM-I, contains NIST-wide policies and procedures and additional sub-level quality documentation contains policies and procedures established and maintained by each Division or Office to meet its technical needs.[9] The

[9]NIST, *NIST Quality Manual for Measurement Services,* NIST-QM-I (December 27, 2016).

system is overseen by the NIST Quality Manager, a position within the Standards Coordination Office, and the NIST Measurement Services Council, comprised of the Quality Manager and other agency officials, who report to the Associate Director for Laboratory Programs.

Private sector calibration and testing companies may use NIST's measurement services to provide NIST-traceable services, meaning that the accuracy and precision of the private company's service has been documented and compared to NIST's capabilities. This process allows these companies to provide services to consumers who do not need the high level of certainty provided by NIST while still providing assurance that their measurements are sufficient for their needs. As shown in figure 3, NIST performed calibrations on about 13,000 individual devices per year and provided about 30,000 reference materials per year or more from fiscal year 2006 to fiscal year 2016. NIST also provides standard reference data—such as detailed technical data on various elements, materials, and chemicals—and keeps time with its atomic clock in Boulder, CO, and broadcasts it. NIST also accredits public and private-sector laboratories to perform calibrations and other tests through the National Voluntary Laboratory Accreditation Program. Such accreditation shows, among other things, that the measurement services provided by these labs comports with certain federal and international requirements for calibration and testing.

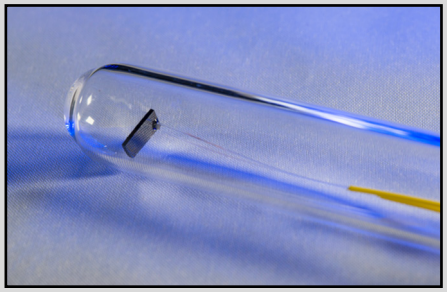
Figure 3: Number of Measurement Services Provided by the National Institute of Standards and Technology (NIST), by Fiscal Year



Source: GAO analysis of National Institute of Standards and Technology (NIST) reference material and calibration services administrative data. | GAO-18-445

Updating the International System of Units

In 2011, the international organization that updates the international system of units approved a plan to redefine four of the base units in metrology: the kilogram (a measure of mass); the ampere (a measure of electrical current); the kelvin (a measure of temperature); and the mole (a measure of the amount of a substance). The new definitions of these units are based on fixed, fundamental constants, like the speed of light and will allow metrology labs like the National Institute of Standards and Technology (NIST) to develop more precise measurement standards and new measurement tools. For example, by moving away from the physical kilogram specimen currently used, the new definition of the kilogram will simplify how NIST and other national metrology institutes ensure consistency across measurements. According to NIST, the agency hopes to take advantage of the use of these fundamental constants to build new measurement tools that provide measurements of the highest quality at less cost and complexity. The NIST-on-a-Chip program seeks to enable modern silicon fabrication processes to mass-produce a single chip-scale device capable of performing measurements that currently require the advanced facilities at NIST and similar specialized laboratories.



Source: NIST. | GAO-18-445

Photograph of a thermometer prototype.

NIST's standards activities support the development and use of standards to enhance the economic and technological competitiveness of the United States. There are various types of standards including measurement standards that define specific units, such as the kilogram, and documentary standards that describe the performance or design of a particular product, process, or test. NIST develops and refines numerous measurement standards and collaborates with other national metrology institutes across the world through the General Conference on Weights and Measures, the Bureau International des Poids et Mesures, and other organizations.[10] This work includes supporting the International System of Units, which includes the kilogram, meter, second, and other units of measurement that form the basis for NIST's calibration services. Measurement standards ensure that these units are consistently used and applied around the world. Documentary standards, in comparison, can specify how a product is designed or made, or they may establish performance standards that define the product by function rather than material. For example, documentary standards define Wi-Fi radios, certain aspects of building codes, and safe design for children's toys, among other things. Both of these standards help define the properties and functions of today's products and provide businesses and consumers with confidence that products will work as expected before purchase.

[10]The General Conference on Weights and Measures and the Bureau International des Poids et Mesures are intergovernmental organizations formed by the Metre Convention to coordinate measurement worldwide, among other objectives.

The U.S. Documentary Standards-Setting Process and NIST Participation

In the United States, documentary standards are generally developed by the private sector through an open, consensus-based process overseen by various SDOs. Private sector companies in the United States choose when it is in their interest to participate in standards development. Many SDOs follow similar processes in the development of standards, and generally adhere to certain principles, including openness, balance of interests, and consensus. Specifically, once an SDO agrees to develop a new or revised standard, a committee is formed of representatives with subject-matter expertise from companies, nonprofit organizations, and government agencies. The representatives serve on a voluntary basis, and the committee drafts the standard. SDOs may have certain requirements for participants, such as payment of membership dues, to fully participate. In the process of creating or revising documentary standards, certain committee members will take on leadership roles, such as chairing committee meetings or leading writing of draft standards or other documents. Generally, a committee will use a consensus-based process to vote on whether to approve the draft standard. For example, to approve a draft standard, some SDOs require a supermajority, at least two-thirds, of the members who cast ballots as well as resolution of any negative comments.

The "Wi-Fi" Documentary Standard for Wireless Networking

Documentary standards define the technical aspects or capabilities of materials, devices, machines, and other products to ensure their performance and interoperability. For example, in 1990, the IEEE Standards Association began work to develop a documentary standard for allowing devices to connect wirelessly to the internet. The IEEE wireless networking working group, designated as 802.11, approved its first standard in 1997 and has since approved a series of amendments and improvements to the standard. In 1999, a group of companies formed the Wi-Fi Alliance to help drive usage of the 802.11 standard and provide consumers with information on products that implement the standard. The Wi-Fi Alliance coined the brand Wi-Fi and developed certification procedures to show that devices using the 802.11 standard from different vendors are interoperable and provide a consistent user experience. Devices that comply with the standard are able to wirelessly transfer data within a local area. Within 2 years of the standard's initial approval, the first devices using the standard were available to consumers and 21 years later wireless networks have become commonplace in libraries, coffee shops, and homes around the world. Originally intended for linking home or office computers, the standard has been implemented in a growing array of devices including lightbulbs and other household items. Hundreds of companies now incorporate Wi-Fi into their products, leveraging the ubiquity of the standard to improve the value of their products and give consumers options for meeting their networking needs.

Sources: IEEE and Wi-Fi Alliance (text); GAO (image). | GAO-18-445

Illustration of a wireless network router.

Several, large private sector organizations help create documentary standards in the United States. The American National Standards Institute (ANSI) is a membership organization that accredits numerous U.S. SDOs that oversee the creation, promulgation, and use of over 10,000 American National Standards. Other U.S.-based organizations that develop standards for domestic and international use include ASTM International, IEEE, and the National Fire Protection Association.[11] ANSI also serves as the U.S. representative to two Geneva-based international organizations that support the creation of global standards, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). When followed, international standards may reduce technical barriers to trade by reducing conflict among domestic standards in various nations and allowing companies to produce a single product for multiple markets. For example, ISO encompasses 163 national standards organizations and is a major source of international standards. In 2000, NIST and ANSI signed a memorandum of understanding to, among other things, improve communication and coordination among the private and public sector on voluntary standards issues.[12]

Staff across many of NIST's laboratories participate in documentary-standards development activities. NIST policy encourages staff participation in domestic- and international-standards activities whenever such participation is in the public interest and is compatible with NIST's mission, policies, positions, priorities, and available resources.[13] In 2016, NIST reported that staff participated in 114 SDOs. In limited policy areas, where a national priority has been identified in statute, regulation, or administration policy, active engagement or a convening role by the

[11]Prior to 2001, ASTM International was known as the American Society for Testing and Materials. IEEE is chartered under the name The Institute of Electrical and Electronics Engineers, Inc., however the organization no longer goes by the full name, except on legal business documents.

[12]Memorandum of Understanding between the American National Standards Institute and NIST (2000). This memorandum recognizes that NIST is to coordinate standards activities with responsible federal agencies to use voluntary consensus standards to the extent practicable, to participate appropriately in their development, and to ensure that they meet federal agency needs.

[13]NIST, *Participation in Documentary Standards Activities*, NIST Policy 5300.00 (Aug. 15, 2012) and *Participation in Documentary Standards Activities*, NIST Order 5301.00 (Oct. 11, 2012).

federal government may be needed to accelerate standards development and implementation.

Federal Agencies' Documentary Standards Activities and Relevant Law and Guidance

Federal agencies may use or help develop documentary standards for several reasons, including (1) to procure goods or services, (2) to incorporate standards into agency regulations, or (3) to improve agency operations or further agency policy goals. For example, the General Services Administration uses standards to specify packaging, marking, and labeling of products purchased for government use and for descriptions of the products themselves; the Consumer Product Safety Commission has incorporated various consensus standards into its regulations of consumer products; and the Department of Energy uses a number of consensus standards to help operate its contractor-run laboratories, among other uses. As a result, a number of federal agencies participate in a range of standards development activities that span many different areas of national need.

Federal law and guidance provide that where possible, agencies are to use voluntary, private sector standards instead of creating their own unique standards and are to establish certain responsibilities in overseeing and coordinating these efforts. The National Technology Transfer and Advancement Act of 1995 (NTTAA) states that federal agencies are generally to use technical standards developed or adopted by voluntary-consensus standards bodies, and in doing so are to consult with voluntary, private-sector consensus standards bodies and participate with such bodies in the development of technical standards when such participation meets certain conditions.[14] NTTAA, as amended, also provides that it is a function of NIST to coordinate the use of private sector standards by federal agencies emphasizing where possible the use of standards developed by private-sector, consensus organizations.[15]

[14]National Technology Transfer and Advancement Act of 1995, Pub. L. No. 104-113, § 12(d), 110 Stat. 775, 783 (1996). Specifically, NTTAA provides that agencies shall—when such participation is in the public interest and is compatible with agency and departmental missions, authorities, priorities, and budget resources—participate with such bodies (voluntary, private-sector, consensus-standards bodies) in the development of technical standards. NTTAA defines "technical standards" as performance-based or design-specific technical specifications and related management systems practices. We use the terms "documentary standards" in this report to encompass standards developed or adopted by SDOs and measurement standards to encompass NIST's efforts relating to defining units of measurement.

[15]We use the term SDOs in this report to encompass private-sector consensus organizations.

Furthermore, the Trade Agreements Act of 1979 (1979 act) directs the Secretary of Commerce to keep adequately informed regarding international standards-related activities and identify those that may substantially affect the commerce of the United States.[16] The Secretary is also to monitor the adequacy of U.S. representation in private international standards activities. The 1979 act says that the representation of U.S. interests before any private international standards organizations is to be carried out by a private person recognized as an organization member.[17] Further, the 1979 act establishes a process for the Secretary to follow if the Secretary has reason to believe that such participation will not result in the adequate representation of U.S. interests or if there is no current organization member. These tasks have been delegated to NIST. NIST's memorandum of understanding with ANSI also describes NIST's role under the NTTAA, OMB Circular A-119, and the 1979 act to, among other things, ensure adequate representation of U.S. interests in all relevant international standards organizations and to coordinate federal activities in voluntary standards.

In addition, Office of Management and Budget (OMB) Circular A-119, as revised in 2016, sets forth the policy for federal participation in the

[16]Trade Agreements Act of 1979, Pub. L. No. 96-39, § 413, 93 Stat. 144, 244 (1979) (codified as amended at 19 U.S.C. § 2543). Under the 1979 act, this role falls to the Secretary of Commerce for nonagricultural products and the Secretary of Agriculture for agricultural products.

[17]The 1979 act defines international standards organizations as any organization (a) the membership of which is open to representatives, whether public or private, of the United States and at least all members of the World Trade Organization; and (b) that is engaged in international standards-related activities. 19 U.S.C. § 2571(6). For purposes of the Secretary's role under section 413, the act defines private international standards organization as any international standards organization before which the interests of the United States are represented by a private person who is officially recognized by that organization for such purpose. 19 U.S.C. § 2543(b)(1)(B). In this report, we use the term international SDO to include these organizations.

development and use of voluntary consensus standards.[18] Federal representatives are encouraged to participate actively in standards development activities and to be fully involved in discussions and technical debates, register opinions, and serve in leadership positions if selected, among other things. A-119 directs the Secretary of Commerce, who has delegated this responsibility to NIST, to foster implementation of the Circular. Further, A-119 provides for a NIST-chaired interagency group called the Interagency Committee on Standards Policy (ICSP). The ICSP is composed of agency standards executives—senior-level officials who are broadly engaged in the agencies' standards activities. A-119 directs standards executives to coordinate their agencies' views when they participate in the same standards activities so as to present, whenever feasible, a unified position and, when not feasible, mutual recognition of differences. A-119 directs the ICSP to coordinate with certain entities with a view to encouraging more strategic and coordinated federal participation in the development and use of standards in regard to regulatory policy. According to the ICSP charter, the ICSP has the objective to promote effective and consistent standards policies in furtherance of U.S. domestic and foreign goals and, to this end, to foster cooperative participation by the federal government and U.S. industry and other private organizations in standards activities, and its purpose is to ensure effective federal participation in domestic- and international-standards activities.

Further, in 2012 the Executive Office of the President (EOP) issued a memo for federal agencies to clarify principles guiding federal government engagement in standards activities that can help address

[18]Office of Management and Budget, *Circular A-119: Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities,* (Washington, D.C.: Jan. 27, 2016). Under A-119, a standard includes: (i) common and repeated use of rules, conditions, guidelines or characteristics for products or related processes and production methods, and related management systems practices; (ii) the definition of terms; classification of components; delineation of procedures; specification of dimensions, materials, performance, designs, or operations; measurement of quality and quantity in describing materials, processes, products, systems, services, or practices; test methods and sampling procedures; formats for information and communication exchange; or descriptions of fit and measurements of size or strength; and (iii) terminology, symbols, packaging, marking or labeling requirements as they apply to a product, process, or production method. The term "standard" does not include professional standards of personal conduct or institutional codes of ethics.

national priorities.[19] According to the memo and A-119, federal engagement in standards activities should be guided by the following strategic objectives:

- Produce timely, effective standards and efficient conformity assessment schemes that are essential to addressing an identified need.[20]
- Achieve cost-efficient, timely, and effective solutions to legitimate regulatory, procurement, and policy objectives.
- Promote standards and standardization systems that promote and sustain innovation and foster competition.
- Enhance U.S. growth and competitiveness and ensure non-discrimination, consistent with international obligations.
- Facilitate international trade and avoid the creation of unnecessary obstacles to trade.

To address these strategic objectives, the memo notes that the federal government works with the private sector to address common standards-related needs, while taking on a more active role where necessary to ensure a rapid, coherent response to national challenges. The memo also identifies responsibilities for agencies, such as periodically reviewing their standards activities to identify gaps in representation for mission-critical areas as part of their long-range planning and ensuring effective intra- and inter-agency coordination of engagement in standards development activities.

[19]Office of Science and Technology Policy, United States Trade Representative, Office of Management and Budget, *Memo on Principles for Federal Engagement in Standards Activities to Address National Priorities*, Memo M-12-08, (Washington, D.C.: Jan. 17, 2012). The memo provides that federal government engagement may be needed in limited policy areas where a national priority has been identified in statute, regulation, or Administration policy.

[20]Conformity assessment is the demonstration, whether directly or indirectly, that specified requirements relating to a product, process, system, person or body are fulfilled.

NIST Faces Several Challenges in Providing Measurement Services and Supporting Documentary-Standards Development

We identified three areas where NIST faces challenges in providing measurement services and supporting documentary-standards development, based on our literature review, NIST stakeholder focus groups, and interviews with stakeholders and agency officials. First, the breadth of U.S. industry and the number of SDOs, among other factors, make identifying and prioritizing measurement service and standards needs and communicating with stakeholders about NIST's services challenging. Second, ensuring adequate U.S. representation in international standards activities can be challenging due to the number of activities and other factors. Third, the involvement of multiple agencies and interdisciplinary issues makes coordinating among federal agencies on documentary standards challenging.

NIST Faces Challenges Identifying and Prioritizing Measurement Services and Documentary-Standards Activities, and Communicating with Stakeholders Can Be Challenging

The breadth of U.S. industries and commercial sectors with measurement-service and documentary-standards needs, and other factors, make it challenging to identify and prioritize among these needs, and make it challenging for NIST to ensure stakeholders are aware of the agency's services.

Identifying measurement-service and documentary-standards needs: Identifying measurement-service and documentary-standards support needs can be challenging, according to participants in all five of our focus groups and other NIST stakeholders we interviewed. Participants and stakeholders identified several factors that contribute to these challenges, including difficulty identifying needs across the breadth of U.S. industries and standards development activities, and difficulties presented by emerging, crosscutting, or interdisciplinary technology areas.

The breadth of U.S. industries and standards development activities can make it difficult to identify their measurement service needs. NIST's potential customer base covers the entirety of the U.S. manufacturing sector and many service sectors, including small- and medium-sized enterprises, as well as federal agencies and state and local governments. Identifying needs across the full range of this customer base can be a challenge, according to participants in all five of our focus groups and other stakeholders. Further, NIST officials noted that even within an industry sector, stakeholders may have differing views on the industry's

measurement service needs, which can make it harder to determine whether or how NIST should take action to meet those needs.

Similarly, the diversity of documentary standards activities across many SDOs may make it difficult to identify when industry needs NIST staff participation in documentary standards efforts. There are no restrictions on which organizations may develop standards, and therefore, the total number of SDOs is not precisely known. However, ANSI estimates that there are hundreds of such bodies in the United States, and NIST has reported participating in 114 separate SDOs. Participants in four of our focus groups and two agency standards executives said that it can be difficult to keep track of SDOs or standards development activities, and NIST standards officials noted that the breadth of active SDOs and volume of their activities was an ongoing challenge. Similarly, three agency standards executives we interviewed said that identifying standards activities of interest to their agencies is challenging due to the large number of activities.

Furthermore, emerging, crosscutting, or interdisciplinary technology areas can be a challenge, according to participants in all five of our focus groups. For example, participants in three focus groups discussed the difficulties faced by organizations that work in areas that combine multiple areas of technical expertise. A participant in one focus group cited electronic health records as an example of an interdisciplinary technology, as it includes biomedical research, public health research, and information technology. Another participant cited increasingly high-tech development in biological devices that involve physics, engineering, and mathematics. Participants said that organizations need to coordinate across disciplines and break down communication barriers to address these challenges. Additionally, representatives from one SDO we interviewed as well as an agency standards executive we spoke with highlighted the difficulty associated with predicting the trajectory of future change in emerging technologies. NIST officials noted that taking action to support the measurement service and standards needs of emerging technologies may be more challenging where there is a lack of industry consensus on how a technology will develop.

Prioritizing among needs: Prioritizing among different measurement services can also be challenging. Participants in all of our five focus groups said that NIST must prioritize among measurement service needs because it does not have the resources to provide services for all industry needs. Participants in three of our five focus groups described challenges balancing between continuing older measurement services that serve

current needs and creating new services. Further, a 2017 review of the activities of NIST's Material Measurement Laboratory by the National Academies found that stakeholders have high demands for the laboratory and that it faces challenges balancing between maintaining ongoing efforts and initiating new efforts. A participant in one focus group also said that it can be difficult to prioritize between services that have broad use and those that are vital to narrower customer bases. For example, NIST performs calibrations for thermometers across a wide range of temperatures for use in many different sectors. On the other hand, NIST's million-pound deadweight machine provides calibrations for very large force gauges used by aerospace manufacturers and the U.S. military. Focus group participants and NIST officials said that the volume of services provided may not reflect the value of the service to the industry, because a single calibration can support many millions of dollars of economic activity.

When prioritizing staff participation in documentary standards activities, NIST faces a similar challenge. Specifically, the abundance of ongoing standards development activities means NIST staff may have to choose among several standards development activities in their areas of expertise. While some staff may have expertise that is closely linked to a small number of SDOs and activities, others may have expertise in foundational technologies that have relevance to numerous activities. Further, a participant in one focus group and two agency standards executives we interviewed stated that standards need to be revised from time to time, for example, to incorporate new technologies, and these revisions may compete for time and attention against new standards efforts in related areas. While individual SDOs can plan for and prioritize among their new standards efforts and revisions, NIST staff who participate in standards development efforts across a number of SDOs may still have to choose among contemporaneous efforts.

Communicating with stakeholders: Communicating with stakeholders about NIST's measurement services can be challenging, according to participants in all five of our focus groups and other stakeholders. Specifically, the breadth of potential users of NIST's measurement services makes it more difficult for NIST to communicate with industry about its needs and NIST's services.

Participants in four of the five focus groups said that it can be difficult for potential users to be aware of and understand the services NIST provides relevant to their needs. For example, participants in one focus group described concerns regarding how well they, and industry stakeholders

generally, understand the extent of NIST's capabilities within their areas of expertise. Participants in this focus group cited benefits of having NIST and industry staff perform site visits to elucidate each other's needs and capabilities. One NIST calibrations official we interviewed said that some commercial sectors, such as the automotive industry, may be underserved by NIST's services due to a limited understanding of how NIST could help companies remain innovative and competitive. However, participants in one focus group said that NIST's engagement with the industrial community is generally quite strong.

Other stakeholders suggested that NIST faces an increasingly difficult task educating potential customers about its services because those customers may have less technical expertise today than they did in the past. Participants in one focus group, officials from the Department of Energy, and a NIST reference material official said that the portion of the nation's workforce trained in measurement and standards issues is shrinking and that industry representatives now have less experience in these matters than they used to. Accordingly, NIST now communicates with stakeholders who have less expertise about its measurement services.

Ensuring Adequate U.S. Representation in International Documentary-Standards Activities Can Be Challenging

According to NIST standards officials, focus group participants, other stakeholders, and a NIST report on U.S. representation in international documentary-standards activities, ensuring adequate U.S. representation in these activities can be challenging. Several factors, such as the large number of international standards activities occurring across numerous industry sectors, underlie this challenge and make it difficult for NIST to ensure adequate U.S. representation.

First, the breadth of the global economy and the volume of international documentary-standards development activities make ensuring adequate U.S. representation challenging, according to NIST standards officials, stakeholders, participants in two focus groups, and literature we reviewed. For example, NIST standards officials, two agency standards executives, participants in one focus group, and literature we reviewed said that the large number of SDOs and volume of international standards activities presents a challenge to NIST. A participant in a different focus group also said that in some cases, industry is reliant on NIST to provide them with information on international standards activities relevant to them. As the number of activities increase, it can be difficult to maintain a comprehensive understanding of what is happening in various industry sectors and standards areas. Further adding to this challenge, several

sources of information we collected identified a significant increase in the number of international standards activities or the relative participation of other countries in these activities, for example:

- NIST officials and participants in one focus group said that international SDOs, such as the ISO, are expanding their efforts to create global standards. Participants said that ISO's efforts could conflict with existing standards that U.S. industry uses.
- Two stakeholders we interviewed said that U.S. industry also faces increasing competition from other countries, such as China, which, in some cases, is overwhelming the ability of U.S. industry to participate. Further, according to a 2012 testimony to Congress by the director of NIST's Standards Coordination Office, other countries have made significant investments in their standards efforts and have attempted to increase their participation in international standards activities.[21] According to the testimony, other countries increasingly view standards as a tool to increase their international competitiveness and are developing strategies and tactics to play a greater role in standardization, such as increasing their participation and leadership in international standards bodies.
- A 2014 NIST report on U.S. representation in international SDOs showed that the United States fell from first in 2005 to second in 2012 in the number of experts participating in one international SDO, the IEC, which produces standards for electric and electronic products, systems, and services.[22] Specifically, the number of technical experts from the top ten countries that participate in the IEC was 5,528 in 2005 and 9,199 in 2012—an increase of 66 percent. However, participants from outside the United States were responsible for 85 percent of the increase. Additionally, the report showed that the United States fell from third in 1999 to fourth in 2012 in the number of IEC standards proposals submitted. The report showed that the number of new IEC standards proposed by all countries was 70

[21]*Promoting Innovation, Competition and Economic Growth: Principles for Effective Domestic and International Standards Development, Before the House Subcommittee on Technology and Innovation*, 112th Cong. 10-23 (2012) (statement of Mary Saunders, Director of the Standards Coordination Office, National Institute of Standards and Technology).

[22]NIST, *A Review of U.S.A. Participation in ISO and IEC*, NISTIR-8007, (June 2014). The purpose of this report was to describe U.S. participation in ISO and IEC standardization activities during the years 1966 to 2012, as well as providing other information related to international documentary standards activities.

proposals in 1999 and 124 proposals in 2012—an increase of 77 percent. However, the percentage of U.S. country proposals out of all country proposals fell from 19 percent in 1999 to 14 percent in 2012.

NIST standards officials said that there could be additional factors driving changes in U.S. stakeholder participation in international SDO activities. For example, NIST officials said that while U.S. stakeholder participation in ISO and IEC may have declined in some cases, some U.S. stakeholders have increased participation in other international SDOs whose standards are better suited for their industry.

Second, what constitutes adequate representation is currently unclear, according to NIST's 2014 report on U.S. representation in ISO and IEC activities and NIST standards officials we interviewed. According to NIST's 2014 report, there are no guidelines or definitions given for what is deemed to be adequate representation of U.S. interests in international standards activities. Further, NIST standards officials said that it was not clear what circumstances would lead NIST to use the process established under the 1979 act if U.S. representation in an international SDO may be potentially inadequate.[23] NIST officials also said that defining what would constitute adequate U.S. representation at international SDOs and collecting the information to help assess the adequacy of U.S. representation would be difficult and the definition and metrics could vary by industrial sector.

Third, according to participants in two focus groups, the large number of companies and other stakeholders that could be involved in or have an interest in various international SDO activities under the U.S. system of private-sector-led standards development can make ensuring adequate U.S. representation a challenge. For example, participants in two focus groups said that NIST would need to consult with numerous industry stakeholders or SDOs to facilitate representation in situations where U.S. representation was inadequate. Further, as we mentioned above, documentary standards needs in emerging, crosscutting, or interdisciplinary technology areas can be a challenge. Literature we

[23]The process set forth in the 1979 act includes notifying the relevant organization member and giving the member the opportunity to demonstrate its willingness and ability to represent adequately U.S. interests before the private standards organization. If the member does not respond or does not demonstrate its willingness and ability to represent adequately U.S. interests, or a private international standards organization has no organization member, the Secretary shall make appropriate arrangements to provide for the adequate representation of U.S. interests. 19 U.S.C. § 2543(b).

reviewed highlighted the need for NIST or other agencies to help bring together industries or other stakeholders that may not have a history of collaborating to resolve standards issues.

Coordinating Federal Agencies' Participation in Developing Documentary Standards Can Be Challenging

Fulfilling NIST's role to work with other agencies to coordinate use of and participation in standards activities under the NTTAA, as chair of the ICSP, and in implementing OMB Circular A-119 is challenging due to (1) the involvement of multiple federal agencies in documentary standards activities, and (2) increasingly interdisciplinary technology areas.

Multiple agency involvement: Multiple federal agencies are involved in documentary standards activities, a situation that can make coordinating agencies' activities challenging, according to participants in all five of our focus groups, and some stakeholders and agency standards executives we interviewed. Because multiple agencies are involved in documentary standards, agency efforts can be fragmented.[24] Fragmentation refers to those circumstances in which more than one federal agency (or more than one organization within an agency) is involved in the same broad area of national need and opportunities exist to improve service delivery.[25] We have previously reported that fragmentation of federal efforts occurs in a number of areas and can lead to challenges to effective coordination.[26] As we mentioned earlier, federal agencies may use or help develop documentary standards for several reasons, including (1) to procure goods or services, (2) to incorporate standards into agency regulations, or (3) to improve agency operations or further agency policy goals. As a result, a number of federal agencies participate in a range of standards development activities that span many different areas of national need. Further, while some documentary standards issues may only affect the mission or activities of a limited number of agencies, other issues may affect many agencies.

[24]For example, as of June 2018, 37 federal agencies are members of the ANSI Government Members Forum, an administrative group composed of government agencies that are members of ANSI. The forum's functions include discussion, networking, and identifying relevant trends, such as international and domestic standards activities of interest to government agencies.

[25]GAO, *Fragmentation, Overlap, and Duplication: An Evaluation and Management Guide,* GAO-15-49SP, (Washington, D.C.: Apr. 14, 2015).

[26]GAO-15-49SP.

Participation by multiple federal agencies in documentary standards activities can be beneficial, according to some focus group participants, stakeholders, and agency standards executives. Some focus group participants, stakeholders, and agency standards executives identified examples of federal participation in which agencies could leverage their different strengths and expertise. For example, participants in four focus groups and some stakeholders we interviewed noted NIST's unique role as a non-regulatory and neutral agency in facilitating the development of standards. These participants and stakeholders said that, in combination with NIST's technical capability, this role allowed NIST to gain trust and cooperation from industry in advancing standards development, whereas industry may view regulatory agencies as less neutral. Participants in one focus group said that this role was also helpful to regulatory agencies because these agencies, such as the Food and Drug Administration, would not be able to work as closely with industry in regard to solving technical standards problems or assisting industry because of their regulatory role. Further, two agency standards executives said that some standards activities benefit from the expertise of multiple agencies. For example, one agency standards executive said that evaluating whether standards or product specifications in other countries constituted a barrier to trade required the expertise and participation of different agencies. Two stakeholders we spoke to also said that participation by all relevant federal agencies in standards activities is beneficial because the agencies can provide technical expertise and are important stakeholders for standards efforts because agencies regulate industry, develop policy, and procure goods from the private sector.

At the same time, participants in all five of our focus groups, some stakeholders, agency standards executives, and NIST officials we interviewed cited challenges in coordinating documentary standards among multiple federal agencies, for example:

- Some stakeholders, agency standards executives, and another federal standards official we interviewed said that communication between federal agencies on their standards activities can be a challenge. For instance, three agency standards executives and one stakeholder said that it can be difficult to identify when other agencies are working on the same standards areas, and two of the standards

executives said it can be difficult to know who to contact in other agencies to coordinate efforts.[27]

- Three agency standards executives said that it can be difficult for standards executives to be fully aware of all standards activities in their department or agency. One standards executive also said that some standards executives have split responsibilities and are not full time, a situation that may make it difficult for these executives to devote sufficient time to understanding their agencies' standards activities, particularly in large agencies. Further, NIST officials said that there is an uneven level of interest and focus on standards as a policy issue among federal agencies, generally.[28]
- Participants in three focus groups cited differing priorities and interests among federal agencies as a challenge to coordinating on standards activities. For example, participants in one focus group said that different interests and priorities among financial regulatory agencies posed a challenge to coordination on cybersecurity standards. As we reported in December 2015, NIST undertook a collaborative process that involved federal agencies as well as nonfederal stakeholders in developing a cybersecurity framework in response to executive order and legislative requirements.[29] Participants in one focus group noted NIST's efforts to work with a variety of public and private-sector stakeholders but also said that financial regulatory agencies have their own cybersecurity regulations that may not align with NIST's framework. In a February 2018 report on implementation of the cybersecurity framework, we noted the complex regulatory and cybersecurity environment of the financial sector and noted that sector representatives said that agencies' differing cybersecurity requirements led to competition among various cybersecurity frameworks.[30]

[27]GAO-12-1022. In 2012, we reported that different agencies participating in any collaborative effort bring different organizational cultures to it, which can make it difficult to operate across agency boundaries.

[28]GAO-06-15. In 2005, we reported that without committed leadership by those involved in the collaborative effort, from all levels of the organization, it can be difficult to overcome the barriers to working across agency boundaries.

[29]GAO, *Critical Infrastructure Protection: Measures Needed to Assess Agencies' Promotion of the Cybersecurity Framework,* GAO-16-152 (Washington, D.C.: Dec. 17, 2015).

[30]GAO, *Critical Infrastructure Protection: Additional Actions Are Essential for Assessing Cybersecurity Framework Adoption*, GAO-18-211 (Washington, D.C.: Feb. 15, 2018).

- NIST officials also said that it can be challenging for federal agencies to harmonize their views on standards because they each have individual missions and priorities that may lead to varying views. Similarly, a 2011 National Science and Technology Council report cited a lack of coordination among agencies with interests in standards activities as having a negative impact on government effectiveness.[31] The report noted that agency objectives may not always be aligned and that they may be providing redundant support or competing with one another.[32]

An additional complexity to coordination of federal agencies' documentary standards activities is that some standards issues may have multiple venues for interagency coordination. NIST officials said that agencies participated in the U.S. private-sector-led standards system and that there were a number of different organizations and groups through which federal agencies shared information, depending on the standards activity. There are at least four groups including the ICSP that provide interagency coordination on standards issues generally.[33] According to NIST officials, interagency coordination also occurs through the National Science and Technology Council's committees and subcommittees. Further, individual documentary standards areas may have additional interagency coordination venues. For instance, interagency coordination on cybersecurity standards also occurs through the Interagency International Cybersecurity Standardization Working Group, according to a NIST 2018 draft report.[34] This group was established by the National Security Council's Cyber Interagency Policy Committee to coordinate on major issues in international cybersecurity standardization and enhance U.S. federal agencies' participation in these efforts. Furthermore, agencies

[31]National Science and Technology Council Subcommittee on Standards, *Federal Engagement in Standards Activities to Address National Priorities: Background and Proposed Policy Recommendations* (Washington, D.C.: Oct. 10, 2011). The Council reported on, among other things, views of respondents to a Request for Information on agencies' standards participation.

[32]GAO-12-1022. In 2012 we reported that participants in collaborative processes may not have the same overall interests, and may have conflicting interests.

[33]The four groups that provide for interagency coordination on standards issues generally are the ICSP; the Technical Barriers to Trade Subcommittee of the Trade Policy Staff Committee; the Regulatory Working Group; and the Joint Enterprise Standards Committee.

[34]Interagency International Cybersecurity Standardization Working Group, *Draft Interagency Report on Status of International Cybersecurity Standardization for the Internet of Things (IoT)*, NISTIR-8200, (February 2018).

may coordinate amongst themselves informally on specific standards interests, according to two standards executives.

Interdisciplinary technology areas: Documentary standards development issues have become increasingly interdisciplinary—potentially creating challenges to coordinating agencies' standards activities, according to our prior work, literature we reviewed, focus groups we conducted, and stakeholders we interviewed. As described above, technology areas, including emerging areas of technology such as electronic health records, can cut across disciplines. According to literature we reviewed, our prior work, and stakeholders we interviewed, interdisciplinary standards can be more difficult to develop or implement because they can be complex and involve a broader range of industry and government stakeholders with potentially different interests and needs. Standards areas are also becoming increasingly interdisciplinary, according to literature we reviewed, one stakeholder, and participants in one focus group. In addition, participants in all five focus groups and some stakeholders we interviewed said that it can be challenging to facilitate interagency coordination on interdisciplinary standards areas. For example, some participants and some stakeholders said that these standards areas can involve the need for collaboration among multiple agencies that can have different roles and responsibilities, priorities, or levels of expertise. Further, two stakeholders said that it could be a challenge for federal agencies to identify these areas.

Our prior work, participants in two of our focus groups, and an agency standards executive identified several examples of interdisciplinary standards areas that present challenges to interagency coordination:

- In February 2018, we reported that protecting the nation against complex and growing cybersecurity threats required coordination between 10 different agencies, 9 of which had responsibility for coordinating implementation of NIST's cybersecurity framework across 16 different critical infrastructure sectors.[35]
- In November 2016, we reported that improved interagency coordination could help to address challenges SDOs face in using forward-looking climate information—an interdisciplinary standards

[35]GAO-18-211.

NIST and the Smart Grid

Under the Energy Independence and Security Act of 2007, the National Institute of Standards and Technology (NIST) is to coordinate the development of a framework for smart grid interoperability. The smart grid is a planned nationwide network that uses information technology to deliver electricity efficiently, reliably, and securely. The development of the smart grid creates possibilities for consumers and utilities to cut costs, be more energy efficient, and incorporate more renewable energy sources. For example, the smart grid will allow consumers to have nearly real-time information to see how much electricity they are using and its cost. Combined with real-time pricing, consumers can save money by using less electricity when it is most expensive. While the smart grid presents many benefits, it is a complicated effort. According to NIST, hundreds of standards will be required to ensure the building of an effective smart grid. Further, because many different users, industries, and components with diverse requirements are involved in the smart grid, standards need to be developed so that the different components in the grid work together effectively. To manage this effort, NIST launched a three-phase plan, which includes:

- Engaging stakeholders to identify priorities for standardization activities.
- Establishing a private-public partnership to coordinate standards development with different stakeholders.
- Implementing a testing framework.

Source: NIST. | GAO-18-445

Photo of a smart meter.

area that requires expertise from multiple agencies—and we made a related recommendation.[36]

- One focus group participant identified open source software and a participant in a different focus group identified machine learning and artificial intelligence as interdisciplinary standards areas needing increased coordination among federal agencies.[37]
- One agency standards executive also said that federal coordination could be beneficial for developing standards for "Big Data" because multiple federal agencies have expertise in Big Data that is not being leveraged to create standards that could facilitate appropriate use of Big Data-related technology and techniques.[38]

According to NIST officials, developing documentary standards for interdisciplinary technologies can be more resource intensive because of the need to pull together expertise from different disciplines and potential competition among SDOs in developing a standard. However, NIST officials also noted that standards development for interdisciplinary technologies may not always be more challenging than other types of standards development efforts, when an SDO has willing participants with the necessary expertise. For example, according to a 2010 VCAT report, NIST established a public-private Smart Grid Interoperability Panel to identify, prioritize, and address new and emerging requirements for this interdisciplinary standards area involving many stakeholders and agencies.[39] According to VCAT, the panel allowed for a wide range of participating stakeholders and served as an effective way to determine and incorporate the different needs and interests of participants in a framework that enabled further development of smart grid standards.

[36]GAO, *Climate Change: Improved Federal Coordination Could Facilitate Use of Forward-Looking Climate Information in Design Standards, Building Codes, and Certifications*, GAO-17-3, (Washington, D.C.: Nov. 30, 2016).

[37]For example, standards may be used to help ensure the safety of automated vehicles that use artificial intelligence. GAO reported on artificial intelligence in GAO, *Artificial Intelligence: Emerging Opportunities, Challenges, and Implications,* GAO-18-142SP, (Washington, D.C.: Mar. 28, 2018).

[38]"Big Data" is a term used to describe the large amount of data in the networked, digitized, sensor-filled, information-driven world. Big Data can overwhelm traditional technical approaches and the growth of data is outpacing scientific and technological advances in data analytics.

[39]Visiting Committee on Advanced Technology, *2009 Annual Report,* (Mar. 3, 2010).

NIST Has Taken Steps to Address Challenges in Providing Measurement Services and Supporting Documentary Standards, but Some Efforts Could Be Improved

NIST works to address the challenges it faces in providing measurement services and supporting documentary-standards development in a variety of ways, but opportunities exist to improve some efforts. First, NIST's efforts help address challenges to identifying and prioritizing measurement-service and documentary-standards needs, but some efforts do not fully align with federal guidance or NIST policy. Second, NIST's efforts help support U.S. representation in international standards organizations but may not fully implement its role and address the challenge it faces. Third, NIST's efforts support federal agency coordination on standards issues but do not fully align with selected leading collaboration practices.

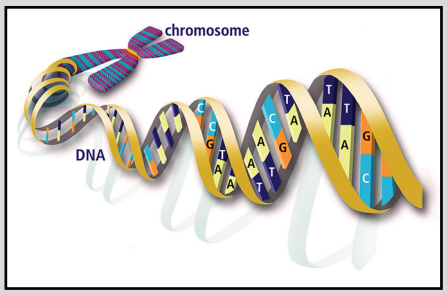
NIST's Efforts Help Address Challenges to Identifying and Prioritizing Needs but Could More Fully Align with Federal Guidance and NIST Policy

NIST takes a variety of steps to identify agency stakeholders' measurement-service and documentary-standards needs, has procedures to support the prioritization of measurement services and standards activities in the agency, and has developed mechanisms for communicating with stakeholders. While these steps help NIST address challenges to identifying and prioritizing needs and communicating with stakeholders, some aspects of these efforts do not fully align with federal guidance or NIST policy.

Identifying measurement-service and documentary-standards needs: NIST identifies stakeholders' measurement-service or documentary-standards needs in various ways, including discussions with industry by NIST technical staff, attendance at trade shows and scientific professional society meetings, workshops hosted by NIST on technology areas of interest, and participation in planning activities of SDOs, among other ways. However, NIST does not regularly perform a comprehensive assessment of its measurement services and standards activities to identify and address any gaps between the agency's efforts and industry needs.

Genome in a Bottle

The Genome in a Bottle consortium is one of several ongoing collaborations among the National Institute of Standards and Technology (NIST), Stanford University, and various industry and government partners that focus on measurements and standards supporting the newest developments in biology. Genome sequencing involves determining the chemical building blocks of deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) and can give insights into the genes carried by an individual and how and when they are activated. Since the completion of the Human Genome Project in 2003 which first sequenced the whole genome of a human, scientists have worked to make whole human genome sequencing faster and less expensive. Genome in a Bottle aims to develop the tools needed to allow clinical use of whole human genome sequencing. These tools include reference materials that allow laboratories to ensure the reliability and accuracy of their sequencing equipment, increasing laboratories' capability to perform genetic testing, medical diagnoses, and customize drug therapies.



Sources: Joint Initiative for Metrology in Biology and GAO (text); Office of Biological and Environmental Research of the U.S. Department of Energy Office of Science (image). | GAO-18-445

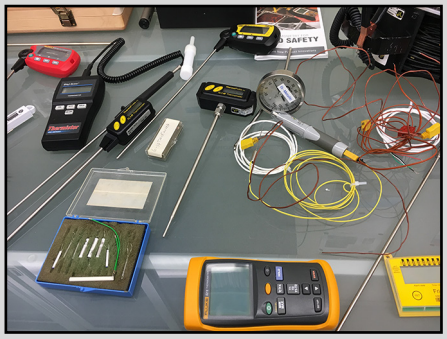
Illustration of a chromosome unraveling to show the base pairings of the DNA.

NIST's primary method for assessing stakeholders' needs is through outreach by individual technical staff and their expertise in relevant disciplines and related industries. Measurement services officials said that NIST's staff work closely with their respective industry stakeholders and others to understand their measurement service needs. They stated that NIST staff engage with industry through direct contact at conferences and trade shows, company and NIST laboratory visits, training, NIST-led workshops, through their ongoing research activities, and other activities. NIST also collaborates with other metrology organizations to identify measurement service needs and advance measurement science. For example, measurement services officials described NIST's participation in international organizations that develop strategic plans for calibrations and measurement standards, such as the Bureau International des Poids et Mesures and Inter-American Metrology System. These organizations allow national metrology institutes, like NIST, to collaborate with their peers and other stakeholders to improve the world's measurement standards and services.

NIST also collaborates with government, industry, and research institutions on emerging issues through various collaboration mechanisms. For example, NIST formed the Genome in a Bottle Consortium in 2011. It provides an open forum for discussion and planning for reference materials and other measurement infrastructure needed to use human genomic sequencing in clinical settings. Similarly, NIST's Advanced Materials Center of Excellence allows the agency to work with universities, a government lab, and others to address research and development needs related to designing novel materials for manufacturing. Furthermore, since 1905 NIST has participated in activities of the National Conference on Weights and Measures. Recent activities of this group include developing measurement practices and measurement standards to ensure that ride-sharing companies accurately measure time and distance charges.

Digital Thermometry: How Measurement Services and Documentary Standards Interact

The National Institute of Standards and Technology (NIST) began an active mercury reduction campaign in 2007 and stopped calibrating mercury thermometers entirely on March 1, 2011. NIST's Temperature and Humidity Group is actively participating in several U.S. and international phasing out efforts to identify alternative thermometers for a broad range of measurement applications, and to coordinate efforts to replace mercury-based instruments. For example, the Minamata Convention on Mercury is a global treaty to protect human health and the environment from the adverse effects of mercury and includes a phase out of the use of mercury in products and processes. According to NIST officials, NIST worked closely with one standards development organization, ASTM International, to develop a new standard for the manufacture and selection of digital thermometers. This standard describes three different types of digital-thermometer sensors and defines different classes of devices based on accuracy and, according to NIST, allowed ASTM to revise over 750 additional standards to replace required mercury thermometers with digital thermometers. NIST provides calibrations for all three types of sensors to the worldwide measurement standard, the International Temperature Scale.



Sources: NIST and ASTM International (text); GAO (photo) |. GAO-18-445

Various thermometers at NIST's temperature calibration lab.

Furthermore, NIST examines trends in the measurement services it provides to better understand industry needs. In particular, NIST conducts individualized testing for companies known as special tests that can give the agency insight into industry's needs. Special tests comprise calibrations and related measurements that are unique to the customer and are not part of NIST's regular catalogue. A company may request a special test, for example, to evaluate a prototype product or measurement technology. According to NIST officials, NIST uses special tests as a way to meet industry needs and also understand what kinds of measurement services industry may need more of in the future.

Similarly, NIST standards officials also described staff expertise as important for identifying stakeholders' needs for support in the development of documentary standards. In particular, standards officials described staff participation in roadmapping activities—used to identify and plan for future standards activities in certain fields—sponsored by NIST or SDOs as important opportunities for staff to assess the standards landscape and identify needs. For example, NIST officials noted the importance of NIST participation in ANSI's standards panels and collaboratives, some of which are co-led by NIST staff, for identifying standards needs. NIST also participates in SDO administrative groups, such as the ANSI Government Members Forum, that can alert NIST to important international and domestic standards activities. Through participation in SDOs, NIST standards officials said that NIST may obtain information on international standards activities in which U.S. industry representation is needed. NIST officials said that developing new documentary standards can take from a year and a half up to a decade to complete, and accordingly, NIST considers what the standards industry is likely to need in the next 1 to 5 years.

In addition, NIST gathers information on how its efforts align with stakeholders' needs through feedback from industry customers and external reviews by the National Academies, VCAT, and others. For example, NIST asks the users of its calibration services and standard reference materials to respond to customer satisfaction surveys. NIST measurement services officials said that while a small percentage of customers respond to the surveys, the information gathered provides useful input on what new services customers need. By 2018, NIST implemented new information systems to track its measurement services' sales and customers, and is evaluating if the agency's outreach to these customers can be improved using the new systems. According to NIST officials, NIST also receives feedback when stakeholders contact the agency through phone, email, or the NIST website. Further, the National

Academies evaluated NIST's Material Measurement Laboratory in 2017 and has reviewed every NIST laboratory since the 2010 reorganization. In a 2017 report, the National Academies recommended that NIST's Material Measurement Laboratory develop a strategy to balance between existing product support and the research, production, and certification of new standard reference materials.[40] Recent VCAT reports have also considered how well NIST identifies measurement-service and documentary-standards needs of its customers and assessed the agency's services:

- In a 2009 report, VCAT examined NIST's participation in standards development in three specific areas and found that NIST's technical expertise, its reputation as an unbiased and neutral party, and its extensive participation in standards activities strongly position NIST to address the standards-related challenges of the 21st century.[41]
- In a 2010 report, the VCAT found that NIST's analysis and planning practices for its measurement services tended to be driven by bottom-up initiatives more than high level strategy and in 2010 and 2011 reports the VCAT recommended, among other things, that NIST perform additional assessments of its measurement services.[42]
- In 2012 and 2013 reports, the VCAT found that NIST's participation in standards activities has helped the agency identify industry needs related to advanced manufacturing.[43]

Additionally, in 2015, NIST received a peer review of its measurement services by experts from other national metrology institutes. According to the peer review summary, most of the eight individuals from other national metrology institutes who reviewed NIST's measurement services found that the agency covered major needs, and the reviewers gave NIST additional feedback on areas for expansion the agency should consider.

[40]National Academies of Sciences, Engineering, and Medicine, *An Assessment of the National Institute of Standards and Technology Material Measurement Laboratory: Fiscal Year 2017* (Washington, D.C.: National Academies Press, 2017).

[41]Visiting Committee on Advanced Technology, *2009 Annual Report* (Mar. 3, 2010).

[42]Visiting Committee on Advanced Technology, *2010 Annual Report* (Mar. 2, 2011) and Visiting Committee on Advanced Technology, *2011 Annual Report* (Mar. 9, 2012).

[43]Visiting Committee on Advanced Technology, *2012 Annual Report* (February 2013), and Visiting Committee on Advanced Technology *2013 Annual Report (*March 2014). The VCAT examined standards activities related to advanced manufacturing and did not assess the agency's standards participation more broadly.

Participants in three of our five focus groups said that when NIST focuses on a specific area, its efforts to understand industry needs can be very effective. For example, participants in one group said that NIST creates an open environment for discussions with industry and companies feel comfortable approaching the agency with their needs. Participants in another group said NIST's regular contact with and surveys of state metrology labs help the agency understand their needs. However, participants in all five of the focus groups said that NIST's capacity for outreach is limited. For example, participants in one focus group said that NIST's outreach efforts can be driven by the personal relationships NIST staff develop with stakeholders and therefore do not scale to the large size of U.S. industry. NIST officials said that its measurement services and documentary-standards support activities serve different populations of stakeholders and that identifying the needs of NIST's measurement services' stakeholders is more manageable than with documentary standards. Specifically, by working with measurement equipment manufacturers, NIST officials said that understanding the needs of its measurement services' stakeholders was manageable. However, NIST officials said it is more difficult to know the measurement-service needs of industry stakeholders that work with equipment manufacturers rather than with NIST directly.

NIST's efforts to identify industry needs are supported by agency policy, and NIST has controls in place to evaluate the efficacy of the measurement services it provides. NIST policy directs staff to consider stakeholders' measurement service needs and assign responsibility for assessing measurement services to agency management. Specifically, the *NIST Quality Manual*, which contains the agency's policies and procedures governing its measurement services, describes meeting and anticipating the needs of measurement services' users as a goal for the agency.[44] The manual encourages staff to identify improvements to measurement services and assigns ultimate responsibility for providing services that meet industry, academia, and other government agency needs to the Associate Director for Laboratory Programs. Further, the *Quality Manual* requires multiple levels of review of the agency's measurement services, including internal audits at the division level, quarterly management review by measurement services officials, and peer-review by a team of experts from other NIST divisions. The assessments are to provide NIST with assurance that its measurement

[44]NIST, *NIST Quality Manual for Measurement Services,* NIST-QM-I (Dec. 27, 2016).

services, and especially the calibration and measurement capabilities, continue to be in compliance with its quality management system. Further, NIST officials told us that the agency was considering measurement services as part of its strategic-planning efforts, but those efforts were preliminary at the time of our review.[45]

For documentary standards, NIST's policies for staff participation in standards development encourages staff participation in domestic- and international-standards development activities whenever such participation is in the public interest and is compatible with NIST's mission, policies, positions, priorities, and available resources.[46] NIST's standards participation policy also provides that the Associate Director for Laboratory Programs conduct periodic reviews of the effectiveness of NIST's participation in documentary standards activities, with support from the Standards Coordination Office. Additionally, the policy directs NIST managers to annually review records of SDO participation by staff in their divisions and calls for laboratory and division managers to periodically review activities to identify gaps in representation for mission-critical areas. Further, NIST officials said that across both measurement services and documentary-standards support activities, the efforts of its staff to meet stakeholders' needs are assessed via employee performance reviews, among other means.

NIST's multi-level assessments of its measurement services and documentary standard development activities help ensure their quality and help to identify stakeholders' needs; however, these assessments do not comprehensively identify and assess gaps in NIST's services or how well they align with stakeholder needs. For example, NIST's efforts to identify measurement service needs for individual technology areas or industries, or to evaluate the services provided by its labs—both areas of

[45]Pursuant to the American Innovation and Competitiveness Act, the Director of NIST, acting through the Associate Director for Laboratory Programs, is to develop and implement a comprehensive strategic plan for laboratory programs that expands (1) interactions with academia, international researchers, and industry; and (2) commercial and industrial applications. Among other things, the strategic plan is to include performance metrics for the dissemination of fundamental research results, measurements, and standards research results to industry, including manufacturing, and other interested parties. American Innovation and Competitiveness Act, Pub. L. No. 114-329, § 107, 130 Stat. 2969, 2987 (2017).

[46]NIST, *Participation in Documentary Standards Activities*, NIST Policy 5300.00 (Aug. 15, 2012), and *Participation in Documentary Standards Activities*, NIST Order 5301.00 (Oct. 11, 2012).

strength for NIST—may not identify gaps in service needs for technology areas not evaluated or that cut across NIST's labs. Officials working on calibration services and reference materials told us that NIST has not performed a comprehensive assessment of how well its services address industry needs since a 2006 assessment of the U.S. measurement system.[47] NIST measurement services officials raised concerns about the value of this type of review, describing the agency's 2006 assessment as time consuming and ultimately of limited use in identifying unmet measurement needs. However, members of the 2015 peer review of measurement services said that NIST would benefit from strategic assessments to identify and assess gaps in programs and a calibration official told us that it is difficult for NIST to recognize if it is not effectively reaching stakeholders. Similarly, NIST officials told us that the Associate Director for Laboratory Programs does not perform a periodic review of the effectiveness of NIST's standards participation, despite the agency's standards participation policy calling for such a review.[48] One standards official said NIST generally does not comprehensively assess standards needs because of the number and diverse nature of standards activities.

Federal standards for internal control direct management to use quality information to determine if the agency is meeting its objectives and to identify, analyze, and respond to significant changes that could present risks to achieving its objectives.[49] In addition, the 2012 EOP memo on standards activities in areas of national priority states that agencies should periodically review their standards activities to identify gaps in representation for mission-critical areas as part of their long-range planning. Revising NIST's policies to provide for periodic comprehensive management reviews of NIST's measurement services would augment NIST's ongoing efforts to assess how well its services align with stakeholder needs and identify any gaps. Conducting comprehensive reviews of NIST's measurement services and documentary standards activities would provide NIST with greater confidence that its activities

[47]NIST, *An Assessment of the United States Measurement System: Addressing Measurement Barriers to Accelerate Innovation,* NIST Special Publication 1048 (August 2006).

[48]NIST, *Participation in Documentary Standards Activities,* NIST Order 5301.00 (Oct. 11, 2012).

[49]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington: D.C., September 2014). Internal controls comprise the plans, methods, policies, and procedures used to fulfill the mission, strategic plan, goals, and objectives of the agency.

align with stakeholders' needs, consistent with internal control standards. Conducting such reviews would also help NIST address the recommendations made by its recent external reviews and could be used to support NIST's efforts to develop the strategic plan called for by the American Innovation and Competitiveness Act.

Prioritizing among needs: NIST has a process for deciding when new measurement services are warranted; however, decision-making about documentary-standards development activities is decentralized, and NIST management and staff may not have clear guidelines or sufficient information to support decision-making about new standards activities.

NIST has processes to guide decision-making about measurement services; this guidance helps address the challenges focus group participants identified given that NIST cannot address all needs. Before choosing to develop a new measurement service, such as a new standard reference material or calibration service, NIST's Office of Reference Materials and Calibration Services office, respectively, consider the need for and priority of the service. One NIST official said that because NIST cannot cover all measurement services that may be needed by the private sector, the measurement services program focuses on the areas where NIST may have the most impact. NIST has procedures in place to evaluate proposals for new services. For example, before NIST develops a new reference material, Office of Reference Materials and relevant laboratory staff annually review proposals for new materials by evaluating factors such as the potential user base for the material, related legislative or regulatory requirements, and whether the material could be produced by other organizations, such as private companies. The Office of Reference Materials also considers these factors when considering extending reference materials it already provides. Further, because developing a new reference material can be time consuming, NIST is currently evaluating the creation of a suite of reference materials called "research-grade materials" that could address high priority areas with a lower level of precision than NIST's standard reference materials. According to NIST officials, research-grade materials are one way of providing this type of measurement service faster to meet the needs of U.S. industry.

Similarly, new calibration proposals are reviewed by Calibration Services management on a quarterly basis and are evaluated on factors such as stakeholder need and potential impact. In addition, NIST extends its reach through its work with private sector test and calibration companies that also serve the needs of U.S. industry. For example, the National

Voluntary Laboratory Accreditation Program allows NIST staff to directly interact with test and calibration laboratories and provides opportunities to share NIST's expertise and improve services offered by these laboratories. Further, a focus group participant and government laboratory officials described industry association meetings as important opportunities to find out about cutting-edge capabilities and potential future measurement capabilities offered by NIST and others.

NIST does not have a similar formalized process to support consistent decision-making across NIST laboratories and divisions about participation in new documentary standards activities. As described previously, NIST's policy for staff participation in standards development encourages staff participation in domestic- and international-standards development activities. Additionally, NIST guidance directs staff to participate in SDO activities based on their unit's mission and goals, and the technical competence required, among other factors, and advises that staff may choose to accept leadership positions in these activities, such as the secretary or chair of a standards committee.[50] OMB Circular A-119 and the 2012 EOP memo on standards also encourage agencies to play a variety of roles in the standards process, such as serving as chairpersons or other official capacities. Focus group participants had mixed opinions on when NIST staff should take on leadership roles. Participants in four of our focus groups said that NIST staff are particularly suited to leadership roles, and some attributed this conclusion to the technical expertise of NIST staff or their ability to act neutrally among competing companies. However, participants in two focus groups said that NIST is better suited to a technical advisor role.

However, NIST policy and guidance do not describe when it is appropriate for staff to take leadership roles in standards development activities. Individual staff in consultation with their supervisors determine what standards activities, if any, they should participate in and their appropriate role in the standards development activity. According to NIST officials, other levels of management may be involved in the decision-making process to varying degrees depending upon whether participation in an SDO activity aligns with a NIST priority or where involvement entails international travel, among other factors. A guidance document for staff encourages them to attend additional training provided by the Standards

[50]NIST, *Guidelines for NIST Staff Participating in Documentary Standards Developing Organizations' Activities,* NISTIR-7854 (May 2012).

Coordination Office, and standards officials we interviewed told us that the training and informal guidance provided by the office could help staff in leadership positions; however, such roles may entail additional time commitments. Although some stakeholders have expressed interest in increasing NIST's participation and leadership in standards activities, doing so could entail tradeoffs between these activities and other NIST priorities. Without clear agency guidance on staff participation in standards development activities, such as the factors staff could consider when deciding to take on leadership or other more active roles, NIST cannot be assured that decisions on the time staff commit to standards activities are being made consistently across the agency and in accordance with agency priorities.

Further, NIST's ability to ensure participation is appropriately prioritized across the many documentary-standards development activities in which its staff could be involved is limited by incomplete information. Staff are directed in NIST policy to record their participation in standards activities in a centralized database, including a description of the SDO, specific activity, and role of the NIST participant.[51] According to a NIST standards official, the database may be used by laboratory managers to assess the standards activities of their staff. However, NIST's database does not contain information regarding NIST staffs' time commitment, information that could be used by management to assess the resources required for participation in these activities. NIST guidelines also direct staff to document their goals and time commitments for standards activities in their individual performance plans, but the data are not included in the standards participation database.

According to NIST officials, determining the time spent on documentary standards can be difficult. Specifically, staff participate in standards development within their areas of expertise and often this work is closely related to their research activities at NIST. Because of this confluence, the amount of time staff spend on a particular standards activity may be unclear. The time spent at meetings or directly drafting or responding to standards documents will also depend on the amount of consensus on the standards committee, consensus that may not be known ahead of time. NIST standards officials told us that the self-reported data currently in the database are sufficient for laboratory management to identify what

[51]NIST, *Participation in Documentary Standards Activities,* NIST Order 5301.00 (Oct. 11, 2012).

activities staff are participating in, and that management can then ask individual staff for additional information. However, NIST does not have data at an aggregate level on the time staff commit to or expect to commit to these activities. Standards for internal control require agencies to use quality information to achieve the entity's objectives, such as by using relevant data from reliable internal and external sources in a timely manner based on the identified information requirements.[52] While staff document their roles in documentary standards activities, without information on the estimated amount of time staff commit to these activities, NIST management may not have the information needed to comprehensively assess how staff distribute their limited time and attention. Although it may not be feasible to determine the exact amount of time spent on documentary standards activities, information on estimated amount of time could help inform staff decision-making on when to accept leadership roles in standards development activities and could inform management on trends in time commitments to these activities across the agency's laboratories and divisions.

Communicating with stakeholders: NIST takes a number of steps to address the challenges it faces communicating with its diverse stakeholders about its measurement services and documentary standards activities. NIST measurement services officials described the primary goal of their stakeholder outreach efforts as informing potential customers of the services NIST provides. The officials described multiple avenues for reaching potential customers of NIST's measurement services, including:

- attendance at workshops, trade shows, and professional societies;
- NIST's measurement services websites;
- email and newsletter correspondence with current customers;
- direct contacts between individual staff and stakeholders; and
- research papers and other scholarly activities.

For example, NIST distributes a newsletter to customers that includes information on upcoming changes to the agency's standard reference materials.

[52]GAO-14-704G.

NIST has also taken steps to better target its stakeholder communication. For example, NIST measurement services officials described an effort to evaluate customer interest in NIST's standard reference materials, as expressed through contact with NIST staff at trade shows. As a result of this analysis, NIST reduced the number of trade shows at which it advertised these materials—focusing on those trade shows that were identified as having the greatest number of interested attendees. More broadly, by 2018 NIST implemented new information systems supporting its measurement services sales, inventory, and customer relationship management. Measurement services officials described efforts currently underway to take advantage of these systems to better target customers by, for example, providing email notifications to customers of new materials or improved measurements of current materials.

NIST's Efforts Help Support U.S. Representation in International Documentary Standards Activities but May Not Fully Address the Challenge

NIST's efforts help support U.S. representation in international standards organizations but may not fully implement its role and address the challenges it faces.

NIST works to support U.S. industry's efforts to ensure that its interests are adequately represented in international standards activities. For example, NIST officials said that NIST staff participate broadly in international standards activities that are aligned with NIST's priorities and share their technical expertise in various committees. Through its participation in SDOs, NIST may obtain information on international standards activities in which U.S. industry representation is needed. NIST also shares information on international standards activities with U.S. industry. NIST hosts the World Trade Organization Inquiry Point, a U.S. government website that serves as a communications hub for information on international standards and related issues. Through the website, U.S. industry and other stakeholders receive notifications of standards-related regulations and procedures, as well as the basis and objective for proposed measures, among other information provided. The website also provides a mechanism to circulate comments on proposed measures. Further, we noted above that NIST participates in ANSI standards panels and collaboratives and the ANSI Government Members Forum. NIST's participation in these bodies can alert NIST to important international standards activities.

NIST officials said that when NIST has become aware of concerns about U.S. representation at an international standards activity within a federal government area of responsibility, it has led efforts to ensure adequate

representation in those activities. For example, according to NIST officials, NIST:

- Worked with the U.S. Patent and Trademark Office to help identify another organization to represent U.S. interests in a standards activity that affected U.S. intellectual property after the original organization decided not to continue participating.
- Established and administered the U.S. technical advisory group for a new ISO technical committee on biotechnology after industry and many federal agencies chose not to participate.[53]
- Took on a leadership role to represent U.S. interests in a standards activity at the International Telecommunication Union when no U.S. telecommunications companies took on responsibility for representing U.S. industry in the activity.[54]

NIST has also issued three reports on U.S. representation in international SDOs. In June 2014 NIST issued its most recent report on U.S. representation in two international SDOs, the ISO and IEC—its two prior reports were published in 2000 and 1988.[55] The 2014 report describes U.S. representation in ISO and IEC activities from 1966 through 2012. As noted previously, the report also describes U.S. memberships and roles in ISO and IEC standards development committees, and includes data comparing U.S. representation on these committees with representation from other countries.

While NIST has helped support U.S. representation in international documentary standards activities, NIST has not developed a mechanism to implement the role delegated to it under the 1979 act to address circumstances when U.S. representation at international standards organizations may be inadequate. As noted previously, the 1979 act directs the Secretary of Commerce to coordinate with the U.S. Trade

[53]Part of ANSI's responsibilities as the U.S. member body to the ISO includes accrediting U.S. Technical Advisory Groups. The primary purpose of these groups is to develop and transmit, via ANSI, U.S. positions on activities and ballots of the Technical Committees (and as appropriate, Subcommittees and policy committees). These technical issues include the approval, reaffirmation, revision, and withdrawal of ISO standards.

[54]The International Telecommunication Union is a specialized United Nations agency that develops standards for information and communication technologies.

[55]NIST, *A Review of U.S.A. Participation in ISO and IEC*, NISTIR-8007, (Washington, D.C.: June 2014).

Representative (USTR) and keep adequately informed regarding international standards-related activities and identify those that may substantially affect the commerce of the United States. The Secretary is also to monitor the adequacy of U.S. representation in private international standards activities. Further, the 1979 act establishes a process for the Secretary to follow to address circumstances in which U.S. representation may be inadequate, specifically:

- If the Secretary, after an inquiry, has reason to believe that the participation by an organization member in the proceedings of a private international standards organization will not result in the adequate representation of United States interests that are, or may be, affected by the activities of such organization (particularly with regard to the potential impact of such activity on the international trade of the United States) the Secretary shall immediately notify the organization member concerned.[56]
- The organization member has a 90-day period following the Secretary's notification to demonstrate its willingness and ability to represent adequately U.S. interests.[57] If the organization member demonstrates willingness and ability, the Secretary should take no further action.
- If the organization member either does not respond or does not demonstrate the requisite willingness or ability to represent U.S. interests or there is no organization member of the private international standards organization—the Secretary is to make arrangements to provide for the adequate representation of U.S. interests.[58]

Although NIST has reported on the extent to which the U.S. participates in some Geneva-based international standards development activities, these reports do not assess the adequacy of this participation. NIST officials we interviewed said that the agency does not assess whether

[56]Inquiries may be instituted on the Secretary's own motion or at the request of any private person, federal agency, or state agency having an interest therein. 19 U.S.C. § 2543(b)(3).

[57]The Secretary may determine a shorter period to be necessary in extraordinary circumstances. 19 U.S.C. § 2543(b)(4).

[58]In cases where there is an organization member, the Secretary should work with the organization member if the international organization requires representation by that member. 19 U.S.C. § 2543(b)(5).

U.S. interests are adequately represented and does not have definitions of or guidelines for what constitutes adequate representation. NIST officials also told us that the agency has not evaluated the circumstances under which it would follow the procedures under the act for addressing inadequate representation. Federal standards for internal control indicate that management should identify, analyze, and respond to risks related to achieving an agency's objectives.[59] As noted previously, the large number of international standards activities occurring across numerous industry sectors, among other factors, present challenges to ensuring adequate U.S. representation in international standards activities.

In commenting on a draft of this report, Commerce stated that a determination to follow the statutory process in the 1979 act would carry significant risk of being perceived by the national and international standards community as a U.S. government change of policy relating to the nation's private-sector-led standards system. However, the memorandum of understanding between NIST and ANSI states that NIST's role, under the NTTAA, OMB A-119, and the 1979 act is "to ensure adequate representation of U.S. interests in all relevant international standards organizations." Further, NIST has previously taken action in some cases in international standards activities within a federal government area of responsibility, as described above. Additionally, the ongoing contacts between NIST and SDOs and staff participation in standards activities can help NIST keep adequately informed on international-standards-related activities.

Without a mechanism to identify and respond to circumstances when U.S. representation at international SDOs may be inadequate, such as guidelines for what constitutes adequate representation and when and how to follow the process under the 1979 act, NIST may miss opportunities to take action in furtherance of its mission to support U.S. competitiveness by helping to ensure adequate U.S. representation in international standards activities. Alternatively, given Commerce's concerns about the statutory process in the 1979 act, NIST could develop a legislative proposal that allows NIST to ensure adequate U.S. participation in international standards activities while addressing those concerns.

[59]GAO-14-704G.

NIST's Efforts Help Support Interagency Coordination, but Opportunities Exist to Better Follow Leading Practices for Enhancing Collaboration

NIST supports coordination among federal agencies on documentary standards issues as chair of the ICSP, as well as additional coordination efforts outside of the ICSP. However, aspects of the ICSP's efforts do not fully align with selected leading practices for enhancing and sustaining interagency collaboration. These practices can help agencies manage fragmentation and other coordination challenges.

NIST has taken several steps to address the challenge of interagency coordination on documentary standards issues through its efforts as chair of the ICSP:

- NIST and member agencies have a charter that outlines the purpose, functions, and membership of the ICSP, among other information. According to the charter, the ICSP was established to advise the Secretary of Commerce and the heads of other federal agencies in matters relating to standards policy. The ICSP's purpose under the charter is to ensure effective participation by the federal government in domestic- and international-standards activities, among other things. NIST officials we interviewed said that the ICSP meets three to four times per year and that the purpose of the ICSP is to promote effective participation by federal agencies in the standards process—when it is within an agency's mission and in the public interest—but not to force their participation. According to NIST officials, NIST tries to demonstrate the benefits of participation and encourages other agencies to participate actively in relevant standards activities.
- NIST chairs and supports ICSP activities, including providing administrative services, organizing meetings, and developing agendas and reports. We previously reported in 2012 that designating a lead agency can assist in driving accountability and providing for continuity of leadership for a collaborative effort.[60] According to NIST officials we interviewed, ICSP meetings are open to agencies outside of the member agencies. Further, NIST officials said they routinely invite staff from non-member agencies when the committee plans to discuss items of particular interest to them. NIST officials said that the ICSP network allows NIST to provide a knowledge base for other federal agencies, and to help federal staff understand standards policy and participation in SDOs, among other things.

[60]GAO-12-1022.

- According to ICSP members and NIST officials, NIST facilitates the sharing of best practices on broad standards topics affecting multiple agencies through the ICSP. As of June 2018, 30 federal agencies have identified participants to the ICSP, while 5 agencies have vacant positions on the committee. NIST officials provided several examples of its information-sharing activities:
  - NIST led ICSP efforts to facilitate discussion on, and manage revisions to, key guidance regarding federal agencies' standards efforts in OMB Circular A-119.
  - NIST led ICSP efforts to promote awareness on and share information related to the development of corporate social responsibility standards in ISO.
  - NIST created an ICSP working group on conformity assessment to help address issues that were frequently being raised during ICSP meetings.
  - NIST invites speakers to share information with ICSP members on various standards-related issues. For example, NIST invited officials from ANSI to present information on standards areas of agency interest and also invited the members of the SDO leading efforts on smart grid standards to brief agencies on the SDO's efforts.

According to six agency standards executives we interviewed, the ICSP helps members to share information, including best practices and to have a general awareness of pertinent documentary standards topics. Three agency standards executives said that the ICSP helps standards executives to know each other on a personal basis so that they know whom to contact to coordinate on standards activities. Bringing agency standards executives together through the ICSP can also spur coordination among agencies if a topic of mutual interest is identified. For example, two agency standards executives said that questions and suggestions raised by agencies at the ICSP led to coordination with other agencies on a standards area of mutual interest.

NIST also coordinates with individual agencies on documentary standards activities outside of the ICSP. For example, according to participants in four focus groups, relevant NIST and VCAT reports, and congressional testimonies we reviewed, NIST is particularly strong in bringing relevant federal agencies and other stakeholders together to develop standards and frameworks for individual interdisciplinary technology areas. Such coordination can occur through a variety of methods or groups, such as workshops, that address standards-related

issues. Additionally, four agencies' standards executives said that they coordinated extensively with NIST on specific standards activities. Two of the agency standards executives described how collaboration with NIST on research helped inform their agencies' standards activities. NIST also offers training, such as NIST's standards boot camp, according to federal standards executives. Five agency standards executives said staff from their agencies attended the training and four standards executives said the training had improved their staff's competence in standards.

While coordination between NIST and other federal agencies on documentary standards issues occurs in a variety of ways, the ICSP is the primary body established to facilitate interagency coordination on standards policy, according to NIST standards officials. However, some of the ICSP's efforts to support coordination among federal agencies on standards issues do not fully align with selected leading practices for interagency collaboration we identified in our previous work. Specifically, the ICSP charter has not been updated; ICSP member agencies' roles and responsibilities have not been fully clarified; and the ICSP may not include relevant members to carry out its functions. Additionally, we reported in 2015 that while collaborative mechanisms differ in complexity and scope, following leading practices can help manage fragmentation and other coordination challenges.[61]

ICSP charter: The ICSP charter has not been updated since it was signed in October 2000. According to the charter, the need for and mission of the ICSP was to be reexamined 3 years after the charter was created. However, NIST officials said that the ICSP charter has not been reexamined. We reported in 2012 that agencies that articulate their agreements in formal documents can strengthen their commitment to working collaboratively.[62] We also reported that written agreements are most effective when they are regularly updated and monitored.[63] Further, updating written agreements, such as the ICSP charter, can be an opportunity for members to define common goals and purpose.[64] In addition, focus group participants, stakeholders we interviewed, and literature we reviewed described broad changes in documentary

[61]GAO-15-49SP.

[62]GAO-12-1022.

[63]GAO-12-1022.

[64]GAO-12-1022. This refers to GAO's "Outcomes and Accountability" leading practice.

standards that have led to new challenges. For example, we previously noted the challenges related to emerging interdisciplinary standards issues and the increase in the number of international standards activities, and both of these areas can benefit from federal coordination.

Further, the ICSP charter has not been updated to reflect the 2016 revisions to OMB Circular A-119 or the guidelines provided to agencies in the 2012 EOP memo on engagement in standards activities to address national priorities. For example, the revised A-119 notes several executive orders relating to review and coordination that were not in existence at the time of the charter's creation. Additionally, the EOP memo that outlines agency responsibilities for standards areas of national priority was also not in existence at the time of the ICSP charter's creation. The EOP memo calls on agencies to ensure effective intra and interagency coordination of engagement in standards development activities. Without reexamining and updating the ICSP charter, as necessary, NIST and other ICSP member agencies cannot be assured that their collaborative efforts are best structured to address current standards challenges.

ICSP member roles and responsibilities: ICSP member agencies' roles and responsibilities have not been fully clarified to an extent that would help the ICSP fulfil its purpose, objectives, and functions to gather information and make recommendations to the Secretary of Commerce to strengthen standards policy and coordination. The ICSP charter outlines two basic functions for the committee: (1) gathering, analyzing, and maintaining current information about standards and other specified related information and (2) on the basis of such information, and when appropriate, making recommendations to the Secretary of Commerce to achieve various standards-related objectives, such as strengthening coordination of standards-related policies and activities among federal agencies.[65] The charter also specifies that the ICSP may create task groups as appropriate. However, we found several areas in which the ICSP charter could more fully clarify member agencies' roles and

[65]Specifically, according to the charter, the ICSP shall, when appropriate, make recommendations to the Secretary of Commerce to, among other things: (1) strengthen coordination of standards-related policies and activities among the federal agencies; (2) improve the efficiency within the federal government of standardization efforts with the U.S. private sector; (3) ensure effective representation of the federal government at significant regional and international standards-related meetings and conferences; and (4) encourage the development of agency strategic plans for managing and monitoring use of voluntary standards and participation in standards-related activities.

responsibilities in regard to implementing its functions, purpose, and objectives, for example:

- The ICSP charter does not fully clarify the ICSP role and member agencies' responsibilities for identifying and coordinating on interdisciplinary standards issues that cross agency boundaries. Five agency standards executives we interviewed as well as NIST standards officials described the ICSP as primarily an information-sharing or networking body, with little role in establishing federal positions on standards activities or policy, or making joint policy decisions with respect to specific standards issues. While information sharing is an important component of interagency coordination, OMB Circular A-119 gives agency standards executives responsibility for consulting with other relevant agencies on standards issues to avoid, to the extent practicable, expressing inconsistent views on standards issues. Furthermore, the 2012 EOP memo specifies that agencies should periodically review their standards activities to identify gaps in representation for mission-critical areas and should ensure effective coordination of engagement in standards development activities. NIST officials and one standards executive said that the ICSP could identify emerging or interdisciplinary standards issues that may require more active federal roles and coordination; however, the charter does not specify the ICSP's role and member responsibilities regarding interdisciplinary standards areas that may cut across agencies.
- The ICSP charter does not fully identify member agencies' responsibilities for coordinating on international standards issues. OMB Circular A-119 and the ICSP charter specify that the ICSP has a role in coordinating federal agencies' international standards activities. However, the ICSP charter does not fully identify member agencies' responsibilities toward fulfilling this role. NIST standards officials and one agency standards executive said that the ICSP does not typically address international standards issues, or policy, or coordinate federal positions on international standards. While NIST officials said other USTR-led efforts could help coordinate agencies' international standards activities, a USTR official told us that USTR does not have the technical expertise needed to effectively coordinate multiple agencies' views on standards. Further, the USTR official, one NIST standards official, and representatives from ANSI said that different agencies' positions are taken into account as part of the standards development process at SDOs that have an open process, such as ANSI. However, as mentioned previously, A-119 specifies that the ICSP is to coordinate with other interagency entities with a view to encouraging more strategic and coordinated federal participation in

the development and use of standards. Further, the ICSP charter also specifies that the ICSP is to ensure effective federal participation in international standards activities.

- The ICSP charter does not fully identify member agencies' responsibilities for developing joint recommendations to the Secretary of Commerce. The charter describes eight areas in which the ICSP shall make recommendations when appropriate, including to strengthen agency coordination and to improve the efficiency of standardization efforts within the federal government. Further, the charter specifies an administrative process for voting on ICSP recommendations. However, according to NIST officials, the ICSP has never made a recommendation to the Secretary of Commerce to address a standards-related issue. Further, NIST officials said that the ICSP agencies have not shown interest in acting jointly. NIST officials said that there may be circumstances in which making such a recommendation would be appropriate, for example, to strengthen interagency coordination on interdisciplinary standards issues, although the officials said that the ICSP would try to address issues at a lower level before elevating them to the Secretary of Commerce. Further clarifying agencies' responsibilities may help ensure that the ICSP is able to meet this function of its charter.
- The ICSP charter does not fully identify member agencies' roles and responsibilities for creating and participating in ICSP's task groups. We have previously reported that task groups can be an effective mechanism for agencies to collaborate on joint challenges.[66] NIST standards officials said that one task group has been created and that task groups may be appropriate either (1) when a standards issue may require more focused and sustained monitoring to understand possible effects on U.S. government activities and missions or (2) when an ICSP member suggests the need for a task group and there is a consensus among membership. However, these reasons are not specified in the charter or other documents available on the ICSP website.[67] Further, while NIST officials said that no member has requested the creation of a task group, two standards executives identified standards coordination issues that they thought may benefit

[66]GAO-12-1022.

[67]One document describes the purpose and responsibilities for the ongoing task group on conformity assessment but does not provide information on task groups more generally.

from the creation of an ICSP task group.[68] The charter specifies an administrative process for voting to create an ICSP task group but does not specify what the role of task groups are, why they would be created, or ICSP member agencies' responsibilities in determining the need for and participating in task groups.

We have previously reported that to achieve a common outcome, participating agencies should consider clarifying roles and responsibilities.[69] By agreeing on and clearly defining the roles and responsibilities of the members as well as documenting those decisions, collaborating agencies can clarify which agency will do what, organize their joint and individual efforts, and facilitate decision-making.[70] Without ensuring that member agencies' roles and responsibilities have been fully clarified, NIST and the ICSP may miss opportunities to strengthen agencies' coordination on standards issues, and better ensure effective coordination related to standards activities. Further, without fully clarifying federal agencies' roles and responsibilities, the ICSP may also miss opportunities to address standards challenges noted above, which limit its ability to support U.S. competitiveness.

ICSP membership: The ICSP may not include all relevant agencies as members or invited observers. The ICSP is comprised of certain specified agencies that are represented by their standards executives as described in OMB Circular A-119.[71] A-119 provides that federal standards executives should be broadly engaged in the agency's standards-related activities so as to ensure intra-agency coordination and have sufficient authority to ensure compliance with Circular A-119. In addition, the ICSP

[68]The standards issues mentioned were the need for improved coordination on standards activities across agencies and strategic level training on standards-related issues such as the lifecycle of a standard, among other things.

[69]GAO-12-1022.

[70]GAO-12-1022. Clarity about roles and responsibilities can be documented using a variety of written agreements, such as through policies or memorandums of understanding.

[71]OMB Circular A-119 requires heads of agencies that use standards for regulatory, procurement, or other mission-related activities to designate a standards executive. For purposes of A-119, "Agency" means any executive department, independent commission, board, bureau, office, government-owned or controlled corporation, or other establishment of the federal government. "Agency" also includes any regulatory commission or board, except for independent regulatory commissions insofar as they are subject to separate statutory requirements regarding the use of voluntary consensus standards.

charter allows the Secretary of Commerce to invite additional members—a role which has been delegated to NIST as chair of the ICSP. Consistent with leading collaboration practices, it is important to ensure that all relevant agencies are included in a collaborative effort. In addition, participants should also have full knowledge of relevant resources in their agency, and the skills and abilities to commit relevant resources and contribute to the outcomes of the collaborative effort, among other attributes.[72]

While the chair of the ICSP said that agency standards executives are engaged in understanding their standards activities and that participation in the ICSP is strong, as we noted above, it can be difficult for standards executives to be fully aware of all standards activities in their department or agency, particularly in large agencies. In addition, an agency standards executive, a NIST stakeholder, and NIST standards officials raised concerns about whether standards executives have sufficient time to understand all their agencies' activities and needs, given their other duties, or whether standards executives have the authority to fully coordinate on standards activities. In some cases, agency officials other than the standards executive may have greater knowledge and expertise about specific standards issues. For example, sub-component offices and agencies may have numerous standards-related activities, such as the Food and Drug Administration within Health and Human Services. According to interviews with two agency standards executives, some sub-component agencies may also have more knowledge and expertise in significant standards areas, and some of these areas can affect multiple agencies. According to one NIST standards official, NIST invites additional agencies when it learns that an agency could potentially add value but has not conducted a comprehensive assessment of ICSP membership within the last 5 years. By assessing whether relevant agencies and offices have been invited to participate as members or observers, the ICSP would have greater assurance of its ability to ensure effective participation by the federal government in domestic- and international-standards activities. Further, having relevant parties involved at the ICSP could enhance the ICSP's efforts by ensuring the viewpoints of all relevant agencies are considered.

[72]GAO-12-1022.

Conclusions

In NIST's role as the nation's measurement science laboratory, NIST works to improve how we design, build, and test the technologies around us. Further, NIST's measurement services and support of documentary standards development can directly affect innovation and the nation's economy by helping companies produce better products and compete in the global economy. However, factors such as the breadth of industry needs, number of domestic- and international-standards development activities, and the fragmented nature of federal agencies' involvement in documentary standards development create challenges to NIST's ability to fulfill its mission of promoting U.S. innovation and industrial competitiveness.

NIST has taken steps to address these challenges. For example, NIST's expert scientists and engineers maintain close contact with industry through a variety of mechanisms, and use their expertise to help identify industry needs and to communicate about NIST's services. NIST has also established procedures to help the agency prioritize and evaluate the effectiveness of its measurement services and ensure that supervisors and laboratory management oversee agency staff participation in documentary standards activities. However, NIST has not comprehensively evaluated the extent to which its efforts align with stakeholder needs. Conducting comprehensive reviews of its activities would provide NIST with greater confidence that its activities align with stakeholder needs and may help identify areas not currently served by NIST.

Similarly, NIST could gain confidence in the effectiveness of its participation in documentary-standards development activities:

- by completing the comprehensive review called for in NIST policy,
- by improving its guidance to staff, and
- by taking steps to enhance agency management's understanding of the time devoted to NIST's current efforts.

NIST staff's expertise and lack of bias make them valuable contributors in documentary-standards development activities, but these individuals have limited time for such activities. Without additional guidance regarding the factors staff could consider when deciding to take more active roles in standards development activities, NIST cannot be assured that decisions on when to participate in such activities are made consistently. Further, while determining the exact amount of time spent on any one standards

activity may not be possible due to overlap with other employee duties, examining to the extent possible the aggregate amount of time NIST staff expect to commit to standards development activities could help NIST management assess the agency's participation in these activities.

Further, NIST has a role, delegated by the Secretary of Commerce, to ensure U.S. interests are adequately represented at private international standards organizations but does not currently have a mechanism to use the process under the Trade Agreements Act of 1979 to identify or respond to circumstances when U.S. representation in international standards activities may be inadequate. Developing a mechanism could help ensure that NIST does not miss opportunities to ensure that the United States is adequately represented in international standards activities. Alternatively, NIST could develop a legislative proposal that allows NIST to ensure adequate U.S. participation in international standards activities while addressing any concerns.

Finally, as chair of the ICSP, NIST provides leadership to enhance interagency coordination on documentary standards issues. However, some of the ICSP's efforts do not fully align with selected leading practices for enhancing and sustaining interagency collaboration, as identified in our previous work. Specifically, the ICSP charter has not been updated since 2000 and certain roles and responsibilities for the ICSP and its members are unclear. Further, the ICSP membership may not include relevant members or observers to ensure effective participation by the federal government in domestic- and international-standards activities. Updating the ICSP charter to affirm its mission and to delineate appropriate roles and responsibilities of participating agencies could strengthen interagency coordination through the ICSP on standards development issues and help the ICSP fulfill its role as envisioned under OMB guidance. Moreover, assessing whether relevant agencies or sub-component offices are invited to participate in the ICSP could provide the ICSP with better assurance of its ability to effectively coordinate agencies' standards activities.

Recommendations for Executive Action

We are making a total of seven recommendations to NIST, specifically:

The NIST Associate Director for Laboratory Programs should:

- update NIST policy to include periodic comprehensive management review of the agency's measurement services to assess gaps and ensure alignment with stakeholders' needs, and take steps to ensure that the Associate Director completes the review of NIST's standards development activities (Recommendation 1).

The NIST Standards Coordination Office Director should:

- update NIST policy for staff participation in standards development activities to provide additional guidance, such as the factors staff could consider when deciding to take more active roles, including leading efforts to develop standards (Recommendation 2); and
- assess the feasibility of collecting aggregate data on the estimated amount of time staff spend on documentary standards activities (Recommendation 3).

The Director of NIST should establish a mechanism—such as guidelines for what constitutes adequate U.S. representation—to assess whether U.S. representation in international SDOs is adequate, and when to follow the statutory process for addressing inadequate U.S. representation. If NIST determines that it is unable to implement the process described in the 1979 act without conflicting with current standards policy, the Director of NIST should develop a legislative proposal to address those concerns (Recommendation 4).

The NIST Standards Coordination Office Director, working with other ICSP member agencies, should:

- review and, as necessary, update the ICSP charter (Recommendation 5);
- clearly define ICSP roles and member agencies' responsibilities, such as for identifying and coordinating on interdisciplinary documentary-standards issues and for making recommendations, as appropriate, to the Secretary of Commerce (Recommendation 6); and,
- assess whether additional agencies or sub-component offices should be invited to participate as ICSP members or observers (Recommendation 7).

Agency Comments and Our Evaluation

We provided a draft of this report to the Departments of Commerce, Defense, Energy, and Homeland Security, and Health and Human Services, as well as the Consumer Product Safety Commission, Environmental Protection Agency, General Services Administration, and USTR for their reviews and comments. Commerce provided written comments, which are reproduced in appendix III, in which it generally concurred with six recommendations and disagreed with one. USTR provided technical comments, which we incorporated as appropriate. The remaining seven agencies informed us that they had no comments.

Commerce agreed with our recommendation regarding comprehensive reviews of the agency's measurement services and standards participation, and stated that it will include requiring management review of its measurement services in a future agency order and will have the Standards Coordination Office support the Associate Director's review of staff participation in standards activities. Commerce also agreed with our recommendations regarding guidance on staff participation in standards activities and assessing the feasibility of collecting data on the time spent on documentary standards activities. Specifically, Commerce said that it will consider updates to guidance to staff and will report on the feasibility of collecting data on the time spent on standards activities.

Commerce also agreed with recommendations on improving interagency coordination in the ICSP. It stated that the chair of the ICSP will review the charter and recommend any updates to the committee and will work with existing ICSP members, alternates, and observers to identify other agencies or sub-component offices that may be invited to participate. While Commerce agreed with our recommendation on roles and responsibilities of the ICSP and its members, it stated that the roles and responsibilities of standards executives are effectively stated in OMB A-119. A-119 describes the roles and responsibilities of standards executives in general, such as their responsibilities to promote effective use of agency resources and participation in standards bodies. However, A-119 does not address specific roles and responsibilities with respect to the activities of the ICSP, such as defining the role of the ICSP in establishing federal positions on standards issues. In our 2012 report on interagency collaborative mechanisms, we state that agencies working together to define and agree on their respective roles and responsibilities can help clarify who will do what and identify how to organize individual and joint efforts. We believe that additional efforts by ICSP members to clarify their roles and responsibilities within the framework of the ICSP will improve the effectiveness of the ICSP as a coordinating body.

Commerce disagreed with the recommendation on ensuring adequate U.S. representation in international SDOs, stating that any determination to follow statutory process would itself carry significant risk of being perceived by the national and international standards community as a U.S. government change of policy relating to our private-sector-led standards system. However, we do not perceive a conflict between the private sector leading U.S. standards development, and NIST developing a mechanism to respond to any instances where U.S. representation in international standards efforts are inadequate. NIST has already taken steps, in some cases, to identify or encourage private sector participation in international standards efforts that lacked U.S. participation. Further, the 1979 act does not define what constitutes adequate representation; NIST can develop criteria to allow the agency to take action when appropriate.

In carrying out the 1979 act, the agency could continue to encourage private-sector stakeholders to address any areas determined to be inadequate, allowing NIST to step in only as necessary when the relevant private-sector entities are not adequately representing, and are not willing and able to adequately represent, U.S. interests. We continue to believe that a mechanism to identify and respond to circumstances when U.S. representation at international SDOs may be inadequate would allow NIST to consistently take action in furtherance of its mission to support U.S. competitiveness. However, in consideration of the concerns raised by Commerce, we have clarified our recommendation that NIST either develop a mechanism to carry out the process described by the 1979 act, or develop a legislative proposal to address any concerns arising from the implementation of the act.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Commerce, and other interested parties. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or neumannj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.

John Neumann
Director, Natural Resources and Environment

Appendix I: Objectives, Scope, and Methodology

This report examines (1) the challenges the National Institute of Standards and Technology (NIST) faces in providing measurement services and supporting documentary-standards development and (2) the extent to which NIST has taken steps to address any challenges and how those steps align with relevant federal guidance and policy.

To identify any challenges NIST may face in providing measurement services and supporting documentary-standards development, we began by performing a literature review, including reports on NIST from the National Academies of Sciences, Engineering, and Medicine, NIST's Visiting Committee on Advanced Technology (VCAT), congressional committee hearings on NIST's measurement services, and other sources.[1] We reviewed these sources to identify statements regarding any challenges to NIST's current measurement services and documentary standards activities or statements recommending improvements to these services or activities. For purposes of our analysis, we included NIST's efforts to support measurement standards as a component of NIST's measurement services.

We supplemented our literature review by holding focus groups with NIST stakeholders including: (1) researchers and (2) representatives working with industry, including commercial entities and states' metrology laboratories. To ensure our focus groups contained a diverse group of stakeholders and viewpoints on NIST's measurement services and documentary standards activities, we included participants from a variety of backgrounds. We selected researchers to participate in our focus groups from university scientists in engineering and the physical and biological sciences. We selected industry participants for the focus groups to reflect a range of industrial sectors, including (1) sectors that comprise greater than 1 percent of U.S. gross domestic product, according to Bureau of Economic Analysis data and (2) sectors that the Department of Commerce's International Trade Agency has identified as U.S. export opportunities.[2] Across these sectors we selected industry participants from the following categories: broadcasting and telecommunications;

[1]VCAT is a federal advisory committee that reviews and makes recommendations regarding NIST's general policy and the agency's organization, budget, and programs within the framework of applicable national policies as set forth by the President and Congress.

[2]Bureau of Economic Analysis, *Value Added by Industry as a Percentage of Gross Domestic Product* (released Nov. 3, 2016), accessed Feb. 7, 2017, http://www.bea.gov/iTable/iTableHtml.cfm?reqid=51&step=51&isuri=1&5114=A&5102=5.

chemical products and pharmaceuticals; computer and electronic products and related services; building products and construction; finance and insurance; food and beverage and tobacco products; health care and social assistance; transportation; utilities and energy; defense products; and other manufacturing. We also included representatives from the National Conference on Weights and Measures, an organization of commercial entities and state metrology laboratories, among others, that addresses measurement of commercial products.

After developing our focus group structure and determining our participant categories, we obtained feedback on our approach during discussions with NIST officials and with representatives from standards development organizations (SDO) selected from those that NIST most often collaborates with—the American National Standards Institute, ASTM International, and IEEE.[3] We then used a snowball approach to identify and invite individuals from across our participant categories. Starting with individuals from several SDOs and the VCAT, we asked for suggestions of individuals knowledgeable in measurement services and standards needs of our participant categories. As we received responses and contacted those individuals, we asked them to recommend additional participants. Through this process, we identified and invited nearly 100 individuals to participate in our focus groups, and 58 individuals agreed to participate. To organize our focus groups we asked the individuals who agreed to participate to describe their expertise regarding measurement services and standards development and familiarity with the industrial sectors we identified. We then selected individuals for each focus group based on availability and to include a mix of expertise. We conducted 3 focus groups for representatives from industry and 2 focus groups for researchers. Each focus group included from 5 to 8 individuals. In total, our focus groups included 31 stakeholders. We reviewed transcripts of the focus groups to identify the challenges NIST faces in providing measurement services and supporting documentary-standards development.

We also collected information on the challenges that NIST faces during 36 interviews, including 17 interviews with current and former NIST officials, 10 interviews with officials from other federal agencies, and 9

[3]Prior to 2001, ASTM International was known as the American Society for Testing and Materials. IEEE is chartered under the name The Institute of Electrical and Electronics Engineers, Inc.; however the organization no longer goes by the full name, except on legal business documents.

interviews with representatives from SDOs and other stakeholders. The 10 interviews we conducted with other federal agency officials included 8 agency standards executives—senior level officials with knowledge of, and experience in, standards-related issues at their agencies and who are responsible for coordinating their agency's participation in SDOs, among other responsibilities—or their alternates on the ICSP.[4] The agencies whose standards executives or other officials we interviewed included the Departments of Defense, Energy, and Homeland Security, and Health and Human Services, as well as the Consumer Product Safety Commission, Environmental Protection Agency, General Services Administration, and Office of the U.S. Trade Representative. GAO reviewed our interview notes to identify challenges and NIST's efforts to address these challenges.

To evaluate the steps NIST has taken to address challenges in providing measurement services and supporting documentary-standards development, we drew upon our focus groups, interviews with NIST staff, and reviews of NIST documentation that described the agency's measurement services and standards activities, such as agency policies, orders, and publications. We also conducted a review of existing literature, relevant laws, NIST policy, and other guidance documents to identify federal requirements and guidance. For example, we reviewed the National Technology Transfer and Advancement Act of 1995, Office of Management and Budget's Circular A-119, and Executive Office of the President's *Memo on Principles for Federal Engagement in Standards Activities to Address National Priorities*, among other sources.[5] We compared the steps NIST has taken to address the challenges it faces in providing measurement services and supporting standards development to these policies and guidance.

[4]The qualifications and requirements for agency standards executives are described in more detail in *Office of Management and Budget, Circular A-119: Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities* (Washington, D.C.: Jan. 27, 2016).

[5]National Technology Transfer and Advancement Act of 1995, Pub. L. No. 104-113, 110 Stat. 775 (1996). Office of Management and Budget, *Circular A-119: Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities,* (Washington, D.C.: Jan. 27, 2006) and Office of Science and Technology Policy, United States Trade Representative, Office of Management and Budget, *Memo on Principles for Federal Engagement in Standards Activities to Address National Priorities*, Memo M-12-08 (Washington, D.C.: Jan. 17, 2012).

To evaluate NIST's current steps, we also considered our prior work on federal standards for internal control and on interagency collaboration.[6] Internal control is a process created by an agency's management and other personnel that provides reasonable assurance that the objectives of the agency will be achieved and comprises the plans, methods, policies, and procedures used to fulfill the mission and objectives of the agency. *Standards for Internal Control in the Federal Government* (known as the Green Book), provide the overall framework for establishing and maintaining an effective internal control system and require that agencies perform and document certain actions to establish an effective internal control system. These requirements include:

- that management should identify, analyze, and respond to risks related to achieving the defined objectives;
- that management should use quality information to achieve the entity's objectives; and
- that management documents the results of evaluations to identify internal control issues.

Our work on interagency collaboration describes leading practices agencies can engage in to enhance and sustain collaborative efforts and describes seven key features to consider to implement these practices. We selected the following five features relevant to NIST's leadership of the Interagency Committee on Standards Policy (ICSP) for review:

- Outcomes and Accountability: Have short-term and long-term outcomes been clearly defined? Is there a way to track and monitor their progress?
- Leadership: How will leadership be sustained over the long-term? If leadership is shared, have roles and responsibilities been clearly identified and agreed upon?
- Clarity of Roles and Responsibilities: Have participating agencies clarified roles and responsibilities?

[6]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: September 2014), GAO, *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms,* GAO-12-1022 (Washington, D.C.: Sept. 27, 2012), and GAO, *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, GAO-06-15, (Washington, D.C.: Oct. 21, 2005).

- Participants: Have all relevant participants been included? Do they have the ability to commit resources for their agency?
- Written Guidance and Agreements: If appropriate, have participating agencies documented their agreement regarding how they will be collaborating? Have they developed ways to continually update and monitor these agreements?

We did not review ICSP collaboration with respect to key features regarding resources or bridging organizational culture because we did not fully examine the activities of all agencies participating in the ICSP.

We conducted this performance audit from July 2016 to July 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Focus Group Participants

The following individuals participated in GAO's five focus groups:

Allen Adler, Former Vice President of Enterprise Technology Strategy, Boeing

Kathleen Almand, Vice President for Research, Data, and Analytics, National Fire Protection Association

Karin Athanas, Government and Regulatory Affairs Manager, American Association for Laboratory Accreditation (A2LA)

Robert Austin, Professor of Physics, Princeton University

Karl Bly, Quality Assurance Director, Vermont Thread Gage

Jerry Buendel, Weights and Measures Program Manager, Washington State Department of Agriculture

Rita Colwell, Professor, University of Maryland, and Johns Hopkins University School of Public Health

Ross Corotis, Professor of Engineering, University of Colorado Boulder

Denyette DePierro, Vice President and Senior Counsel, Center for Payments and Cybersecurity, American Bankers Association

Don Detmer, Professor of Public Health Sciences, University of Virginia

Gail Folena-Wasserman, Senior Vice President, Biopharmaceutical Development, MedImmune

Ruben G. Carbonell, Professor of Chemical Engineering, North Carolina State University and Chief Technology Officer, National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL)

Christopher Guay, Regulatory Fellow, Procter and Gamble

Kelvin H. Lee, Professor of Chemical and Biomolecular Engineering, University of Delaware and Director, National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL)

Hani Haider, Director of Orthopaedics Biomechanics & Advanced Surgical Technologies Laboratory, University of Nebraska

Jennie Hwang, CEO and Principal, H-Technologies Group

Walter Jager, Principal, Environmentally Conscious Design (ECD) Compliance

Karen Kafadar, Professor and Chair of Department of Statistics, University of Virginia

Dave Kreitlow, Operations Manager, MTS Systems Corporation

Zhiyong Ma, Vice President and Director of Technology and Manufacturing Labs, Intel

Kristin Macey, Director of Division of Measurement Standards, California Department of Food and Agriculture

Josh Magri, Vice President and Counsel for Regulation and Developing Technologies, Financial Services Roundtable

Dave Maisch, Director of Engineering and Industrial Affairs, PMC Lone Star

Tod Sizer, Vice President of Mobile Radio Research Laboratory, Nokia Bell Labs

Clifford Spiegelman, Distinguished Professor of Statistics, Texas A&M University

Lonnie Spires, President and CEO, American Association for Laboratory Accreditation (A2LA)

Jeff Sprague, Senior Regulatory Affairs Manager, Medtronic

Alan Taub, Professor of Material Science and Engineering and Mechanical Engineering, University of Michigan

Andrew Updegrove, Partner, Gesmer Updegrove LLP

Steve Whitman, Vice President, Coastal Flow Measurement

Ray Xu, Senior Specialist, Rolls-Royce Corporation

Appendix III: Comments from the Department of Commerce

UNITED STATES DEPARTMENT OF COMMERCE
The Secretary of Commerce
Washington, D.C. 20230

July 11, 2018

Mr. John Neumann
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Neumann:

Thank you for the opportunity to review and comment on the Government Accountability Office's (GAO) draft report titled *National Institute of Standards and Technology: Additional Review and Coordination Efforts Could Help Meet Measurement Services Needs and Strengthen Standards Activities* (GAO-18-445).

On behalf of the Department of Commerce, I have enclosed our comments on the draft report. The Department agrees with some of the recommendations, and the enclosed comments provide information regarding planned actions. In addition, we included comments regarding the GAO recommendations with which we disagree.

If you have any questions, please contact MaryAnn Mausser, Department of Commerce Audit Liaison, at (202) 482-8120.

Sincerely,

Wilbur Ross

Wilbur Ross

Enclosure

Department of Commerce's Comments on
GAO Draft Report titled *National Institute of Standards and Technology: Additional Review and Coordination Efforts Could Help Meet Measurement Services Needs and Strengthen Standards Activities*
(GAO-18-445)

The Department of Commerce has reviewed the draft report, and we offer the following comments for GAO's consideration.

Comments on Recommendations
The Government Accountability Office (GAO) made seven (7) recommendations to the Department of Commerce in the report.

- **Recommendation 1:** The NIST Associate Director for Laboratory Programs should update NIST policy to include periodic comprehensive management review of the agency's measurement services to assess gaps and ensure alignment with stakeholder needs and take steps to ensure that the Associate Director completes their review of NIST's standards development activities.

  Commerce Response: The Department of Commerce agrees with this recommendation.

  NIST measurement services are comprehensively reviewed periodically via the NIST Measurement Services Council (NMSC), the documented NIST Quality Management System, regularly scheduled National Research Council technical reviews, and periodic reviews by the Visiting Committee on Advanced Technology and external expert panels. Additionally, internal reviews at the Division level continuously evaluate the impact of NIST measurement service projects. NIST currently reviews and documents a management review of measurement services through the chartered NMSC. NIST will document these ongoing assessment activities in a Directive Order.

  The NMSC objectives are: (1) Identify and address NIST-wide issues related to the quality, relevance, performance, operations, and resources allocated to the health and improvement of NIST measurement services; and (2) Identify and address critical NIST-wide issues affecting measurement services and the national measurement standards underpinning them.

  For documentary standards, the SCO Director will support the Associate Director's periodic review of the effectiveness of NIST participation in documentary standards activities.

- **Recommendation 2:** The NIST Standards Coordination Office Director should update NIST policy for staff participation in standards development activities to provide additional guidance such as the factors staff could consider when deciding to take more active roles, include leading efforts to develop standards.

Commerce Response: The Department of Commerce agrees with this recommendation and will take this recommendation into consideration in any future revision of the specific guidance for staff participation in standards development activities found in NISTIR 7854, *Guidelines for NIST Staff Participating in Documentary Standards Developing Organizations' Activities*.

In accordance with NISTIR 7854, last revised in 2012, the decision to participate in standards developing organization activities, including leadership roles, is made by individual staff in conjunction with their management based on the unit's mission and goals, resource commitments, and the technical competence required. Once the decision is made, staff and management are to add an appropriate element to the staff member's performance plan. The guidance provides that this element should include a clear statement of time and resource commitment to the activity, as well as a set of goals and milestones. Staff accomplishments should be reviewed according to the laboratory's normal practice concerning standards-related activities. However, per NIST Order 5301.00, the final decision to participate is made by NIST management.

- **Recommendation 3:** The NIST Standards Coordination Office Director should assess the feasibility of collecting aggregate data on the estimated amount of time staff spend on documentary standards activities.

  Commerce Response: The Department of Commerce agrees with this recommendation.

  The NIST Standards Coordination Office Director will assess the feasibility of collecting aggregate data on the estimated amount of time staff spent on documentary standards activities and report to the Associate Director of Laboratory Programs.

- **Recommendation 4:** The Director of NIST should establish a mechanism to assess whether U.S. representation in international SDOs is adequate, such as guidelines for what constitutes adequate U.S. representation, and when to follow the statutory process for addressing inadequate U.S. representation.

  Commerce Response: The Department of Commerce does not agree with this recommendation.

  The 1998 National Technology Transfer and Advancement Act (NTTAA), OMB A-119 and the 2012 EOP memo all recognize and advocate the U.S.'s private-sector-led standards system. Any determination to follow "statutory process" would itself carry significant risk of being perceived by the national and international standards community as a U.S. Government change of policy relating to our private-sector-led standards system. Accordingly, NIST will continue to exercise caution and to carefully balance its work in the international standards area to avoid disrupting the private-sector-led system, which has made the U.S. standards system, including U.S. participation in international standards, the most successful system in the world. In this respect, NIST, along with representatives from the Department's International Trade Administration, participated in June of this year in an Executive Roundtable on Strategic Standardization and Competitiveness, hosted by the American National Standards Institute (ANSI). The ANSI event, which generated recommendations

from the private sector to ANSI for strategic engagement in international standards development, included executives from companies with global operations representing a range of industry sectors, including electrical power, heavy equipment, the built environment, advanced manufacturing, glass/optical, information technologies, and services. ANSI is the official U.S. representative to the International Organization for Standardization and, via the U.S. National Committee, the International Electrotechnical Commission. As noted in this GAO report, NIST has acted to secure U.S. representation and leadership in key areas such as biotechnology and nanotechnology and will continue to do so. Additionally, NIST has coordinated with other U.S. Government agencies to ensure U.S. representation and leadership in areas critical to U.S. Government operations, such as biometrics, and will continue that coordination.

Recommendation 5: The NIST Standards Coordination Office Director, working with other ICSP member agencies, should review and, as necessary, update the ICSP charter.

Commerce Response: The Department of Commerce agrees with this recommendation.

The Chair of the ICSP will conduct a review of the Charter in an upcoming ISCP meeting and recommend any appropriate updates for the consensus decision of the ICSP.

- **Recommendation 6:** The NIST Standards Coordination Office Director, working with other ICSP member agencies, should clearly define ICSP roles and member agencies' responsibilities, such as for identifying and coordinating on interdisciplinary documentary standards issues and for making recommendations, as appropriate, to the Secretary of Commerce.

  Commerce Response: The Department of Commerce agrees with this recommendation and notes that this recommendation is effectively addressed in OMB Circular A-119 (rev. 2016).

  NIST observes that ICSP Standards Executives roles and responsibilities are well-defined in Section 14 of OMB Circular A-119. The NTTAA assigns NIST to "coordinate the use by Federal agencies of private sector standards." NIST worked closely with OMB and USTR on the 2016 revision of OMB Circular A-119, which clarifies the roles of Standards Executives. The current OMB A-119 has been reviewed by the ICSP, and the NIST Standards Coordination Office Director will continue to ensure that participating Agency Standards Executives are aware of their roles and responsibilities.

- **Recommendation 7:** The NIST Standards Coordination Office Director, working with other ICSP member agencies, should assess whether additional agencies or sub-component offices should be invited to participate as ICSP members or observers.

  Commerce Response: The Department of Commerce agrees with this recommendation.

  NIST will review the current roster of ICSP Standards executives, alternates and observers and work with existing ICSP Standards Executives, alternates, and observers to identify other agencies or sub-component offices that may be invited to participate as members or observers.

Appendix IV: GAO Contact and Staff Acknowledgements

GAO Contact

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Staff Acknowledgements

In addition to the contact named above, Chris Murray (Assistant Director), Tind Shepper Ryen (Analyst-in-Charge), John Delicath, Justin Fisher, Eli Harpst, Tricia Moye, Danny Royer, Andrew Stavisky, and Sarah Veale made key contributions to this report.

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