NIST INTERNATIONAL ACTIVITIES

NIST

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Technology Administration

National Institute of Standards and Technology

Special Publication 915

The National Institute of Standards and Technology was established in 1988 by Congress to "assist industry in the development of technology . . . needed to improve product quality, to modernize manufacturing processes, to ensure product reliability . . . and to facilitate rapid commercialization . . . of products based on new scientific discoveries."

NIST, originally founded as the National Bureau of Standards in 1901, works to strengthen U.S. industry's competitiveness; advance science and engineering; and improve public health, safety, and the environment. One of the agency's basic functions is to develop, maintain, and retain custody of the national standards of measurement, and provide the means and methods for comparing standards used in science, engineering, manufacturing, commerce, industry, and education with the standards adopted or recognized by the Federal Government.

As an agency of the U.S. Commerce Department's Technology Administration, NIST conducts basic and applied research in the physical sciences and engineering, and develops measurement techniques, test methods, standards, and related services. The Institute does generic and precompetitive work on new and advanced technologies. NIST's research facilities are located at Gaithersburg, MD 20899, and at Boulder, CO 80303. Major technical operating units and their principal activities are listed below. For more information contact the Publications and Program Inquiries Desk, 301-975-3058.

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[1]At Boulder, CO 80303.
[2]Some elements at Boulder, CO.

NIST Special Publication 915

NIST International Activities

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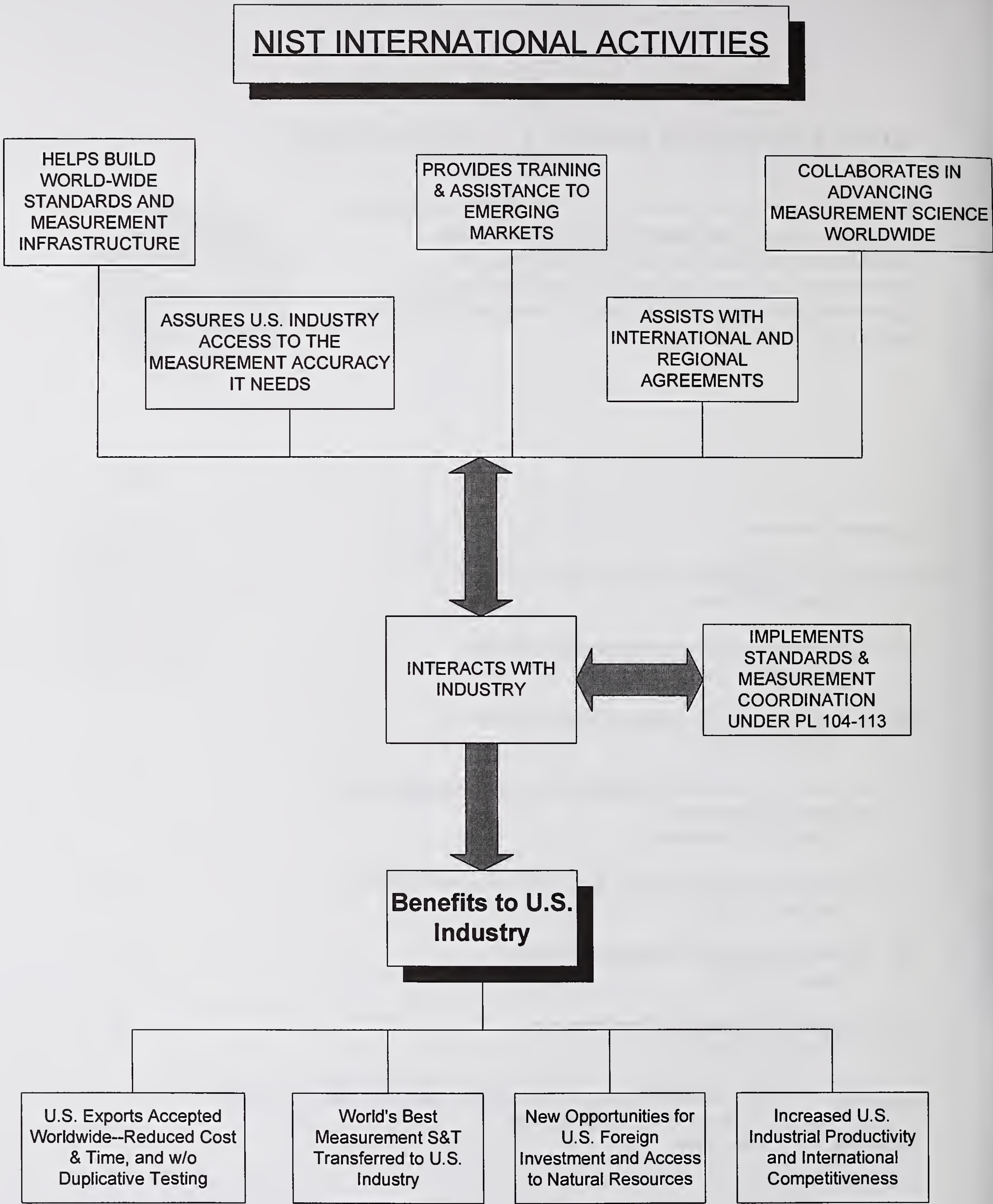
NIST INTERNATIONAL ACTIVITIES

A comprehensive report about NIST's international activities in collaborating on measurement science, delivering measurement services, carrying out research and development, harmonizing standards and conformity assessment, providing training and teaching, and rendering assistance to U.S. industry.


NIST INTERNATIONAL ACTIVITIES
HELPS BUILD WORLD-WIDE STANDARDS AND MEASUREMENT INFRASTRUCTURE
PROVIDES TRAINING & ASSISTANCE TO EMERGING MARKETS
COLLABORATES IN ADVANCING MEASUREMENT SCIENCE WORLDWIDE
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Increased U.S. Industrial Productivity and International Competitiveness

Mar. 1997

NIST INTERNATIONAL ACTIVITIES

Executive Summary

The National Institute of Standards and Technology (NIST) was established by Congress "to assist industry in the development of technology...needed to improve product quality, to modernize manufacturing processes, to ensure product reliability...and to facilitate rapid commercialization...of products based on new scientific discoveries." An agency of the U.S. Department of Commerce's Technology Administration, NIST's primary mission is to promote U.S. economic growth by working with industry to develop and apply technology, measurements, and standards. It carries out this mission through a portfolio of four major programs:

- a strong laboratory effort, planned and implemented in cooperation with industry, that provides technical leadership for the nation's measurement and standards infrastructure;

- a rigorously competitive Advanced Technology Program providing cost-shared awards to industry for research on high-risk technologies with potentially broad-based benefits for the U.S. economy;

- a Manufacturing Extension Partnership through which a nationwide network of locally managed centers offers technology and business assistance to smaller U.S. companies; and

- a highly visible quality outreach program associated with the Malcolm Baldrige National Quality Award.

This report on NIST's international activities focuses on the first of these programs---the NIST laboratory effort. NIST laboratories perform tasks vital to the country's technology infrastructure that neither industry nor the government can do separately. The nation's measurement and standards infrastructure is the basis for confidence in the development and exchange of technical information between scientists and engineers, between providers and purchasers of goods and services, between governments and the private sector, and between governments. NIST plays a central and unique role in ensuring that this critical infrastructure meets the economic and social needs of the nation.

NIST laboratories participate in international activities for two main reasons: (1) because they are a cost-effective way to access the latest thinking along the frontiers of measurement science and technology in other countries, thereby contributing to NIST's mission; and (2) because they help to open foreign markets to U.S. technology-based exports and investment. Secondary reasons are to enhance public safety and health throughout the world and to contribute to U.S. foreign policy objectives such as world peace, the environment, non-proliferation, and economic and social advancement. NIST's international activities are an integral component of the NIST laboratory mission.

This report was conceived and prepared by Technology Services, one of NIST's major operating units, and will be used as a basis for developing a strategic plan for NIST international initiatives in support of U.S. objectives, especially export expansion. The report also responds to the October 1996 Report to the Congress, "The National Export Strategy," by the Trade Promotion Coordinating Committee composed of the Heads of 20 U.S. government agencies and chaired by the Secretary of Commerce. That Report states, "*While we have long recognized the importance of standards in defining future market share for its products, it is evident---particularly in the emerging economies---that the U.S. must develop a more proactive, strategic standards commercial policy to ensure that U.S. companies are not unfairly precluded from competing for contracts in our most promising markets.*" (Appendix 1 contains the Report's recommendations on standards-related matters.)

The scope of this report is broad. It identifies all of the major international activities of NIST, states their rationale in terms of expected benefits to NIST and the U.S. economy, and suggests approaches to solving the problems that currently inhibit full realization of these benefits. As shown in the block diagram in front of this Executive Summary, NIST's international activities can be categorized into five areas. NIST:

- Helps Build Worldwide Standards and Measurement Infrastructure. NIST does this so that the standards and measurement technologies used by our trading partners are consistent with our own technologies, thereby facilitating U.S. trade.

- Assures that U.S. Industry Has Access to the Measurement Accuracy It Needs. Our trading partners (and U.S. domestic industries) will accept nothing less.

- Provides Training and Assistance to Emerging Markets. Unless we do this, the United States will lose tens of billions of dollars in trade and investment opportunities to our European competitors.

- Assists with International and Regional Agreements. U.S. trade negotiators need NIST's technical expertise for the mutual recognition agreements which will eliminate unnecessary costs and delays incurred by U.S. exporters and will open new markets for U.S. products.

- Collaborates in Advancing Measurement Science Worldwide. U.S. leadership in international measurement science and technology is possible only when NIST accesses the best technical judgement from whatever source.

NIST interacts closely with industry when implementing its international activities and its new standards coordinating responsibilities under the Technology Transfer and Advancement Act of 1995 (PL 104-113). It is the S&T infrastructure needs of U.S. industry that drive the NIST research agenda and related international activities. Working together, these five NIST international activities help to produce the benefits cited at the bottom of the diagram, as well as such indirect benefits as bilateral and regional goodwill which, in turn, contribute to other U.S. public policy goals.

NIST's international activities are a vital part of a complex chain of interlinked mechanisms, capabilities, and organizations (both public sector and private sector; both domestic and international) that *together* form the measurement-related infrastructure for U.S. trade in technology-based products and services. This chain is only as strong as its weakest link. For example, even if all international standards used by our trade partners were consistent with U.S. standards, we might not be able to export if those partners refuse to recognize our conformity assessment procedure.

Principal Finding. The responsibilities placed on NIST by the U.S. business community and the Congress for such a domestic and international measurement-related infrastructure that better supports U.S. commercial interests are strong. Our principal industrialized trading competitors devote more resources than we do to international standards and related measurement activities as dedicated instruments of national economic and trade policy, especially in certain industrial sectors and developing economies. That effort will increase competitive exports, often at the expense of U.S. exports. The stakes are high for the United States.

Accordingly, unless NIST mounts a more aggressive effort (in cooperation with U.S. industry and other stakeholders), U.S. exports will be at a long term and serious disadvantage in penetrating foreign markets and maintaining market share. In responding to that challenge and opportunity, NIST will focus on four interrelated objectives in the international arena: (1) maintaining and strengthening U.S. scientific leadership in metrology; (2) effecting a more influential U.S. presence in the major international standards-developing bodies, and in international systems for conformity assessment and quality assurance in manufacturing; (3) encouraging, through technical assistance and training, the adoption of international standards and related

practices (or, in their absence, U.S. standards and practices) by certain high growth-potential countries whose measurement infrastructures are evolving; and (4) helping to gain acceptance by our major trading partners of U.S. testing, conformity assessment, and quality assurance systems. These *international* activities will be integrated with NIST's leadership and coordinating role, as recently mandated and strengthened by the National Technology Transfer and Advancement Act of 1995, in strengthening the U.S. *domestic* standards and conformity assessment infrastructure.

Abstracts of Chapters.

Chapter I: "Economic Roles of Standards in International Trade," by Gregory Tassey

U.S. firms have substantial concerns about the economic effects of standards because this form of infrastructure can either facilitate or inhibit technological innovation, market entry, and opportunities for both exporting and importing. The type of standard that affects an element or attribute of a product can enable large markets to evolve and ensure that investments in the R&D and production capability for products that are complementary to the standardized product will benefit from a single, unified market. U.S. firms exporting into foreign markets want to extend these domestic efficiency gains by conforming to the same product-element standard, or at least incurring minimal costs of adaptation to a different standard. A second type of standard affects the environment in which the product is developed, produced, and marketed. Such standards provide information (test methods), ensure performance (quality specifications), or enable compatibility or interoperability among several products making up a product or service system (interface standards). Thus, both types of standards offer major opportunities for U.S. business. Alternatively, standards can evolve into multiple and inefficient forms, thereby acting as barriers to domestic growth and international trade to the detriment of U.S. economic welfare.

Chapter II: "Collaborate in Advancing Measurement Science" by Katharine B. Gebbie

Metrology, part of this country's "hidden infrastructure," plays a critical role in the modern world, especially the fields of medicine, agriculture, and manufacturing. Any country's measurement infrastructure is ultimately limited by the accuracy and stability of its primary standards. The International Bureau of Weights and Measures (BIPM) establishes the basic standards and scales of the principal physical quantities (such as the meter, kilogram, and second). Since BIPM measurement technology is the basis for international standards, NIST's current leadership role in that organization is important for U.S. trade interests---losses in the U.S. scientific leadership in primary standards translate downstream into lost opportunities in U.S. production of technology-based products and services, and in their export. Yet NIST is not presently competitive with European national laboratories in such areas as realizing the basic unit of time or in frequency-based length standards. U.S. leadership in international measurement technology is credible only to the extent that it is based on the best technical judgement available from whatever source. Accordingly, NIST collaborates with its foreign counterparts on a broad range of projects, and benefits from the cross-fertilization afforded by the over 300 visiting foreign scientists at NIST, as well as multi-country use of unique national measurement facilities. A list of priority metrology research projects needed for NIST to regain wider international leadership in metrology and to meet industry requirements is provided.

Chapter III: "Provide Uniform and Accurate Measurements," by Sharrill Dittmann

NIST plays a critical role in facilitating U.S. exports by helping to ensure the accuracy and credibility of U.S. measurements and measurement services. Currently, there is no universally recognized system to which all trading partners adhere for ensuring measurement accuracy and credibility. U.S. exporters often must have their products tested in the importing country when that country does not recognize the reliability of U.S. tests, resulting in both higher costs and lost markets. The challenge for NIST as the national metrology laboratory is to provide the critical links between the various U.S. testing and laboratory accreditation systems and the U.S. national measurement standards on the one hand, and foreign governments and bodies requiring U.S. Government assurance of the reliability of U.S. test and measurement results on the other. NIST is well positioned to respond to this challenge. NIST staff already are involved in a broad range of related international activities including as U.S. representatives to several international bodies. However, NIST's capability to provide measurement services has continued to erode. In the interest of U.S. international (and domestic) trade, NIST must strengthen these services.

Chapter IV: "Improve U.S. Access to Developing Markets Through Standards Assistance and Training," by Peter L. M. Heydemann

Trade in any market requires an infrastructure that includes not only transportation, mail and telephone systems, electric power, and banking, but also a system of clear and reasonable normative standards, conformity assessments, weights and measures, and import regulations. It also requires competent authorities to set and administer the rules. When these conditions are not fulfilled, when there are arbitrary rules, corruption, or cheating in the market place, then U.S. access to the market is impaired. Many developing markets, and even a few developed ones, do not meet all of the conditions identified above. This chapter discusses the conditions in several developing markets and describes the program that NIST Technology Services is embarking on to improve access to those markets. We concentrate here on influencing authorities to set reasonable normative standards compatible with U.S. or international patterns; to recognize the results of testing done in the United States; and to provide fair weights and measures services. The major tools for achieving these objectives are to establish relations with other governments based on mutual trust and confidence; to provide training, advice, and consultation; and to assist in the establishment of appropriate organizations. This will then be the basis to achieve the objectives described elsewhere in this report for the harmonization of normative standards, for the evolution of a worldwide system of uniform and accurate measurements, and for reaching the elusive goal of "one product, one standard, one conformity assessment." This work is urgent. Other nations are many years ahead of us in establishing systems in developing markets that favor their traders and exclude ours.

Chapter V: "Support International Standards and Harmonization Efforts," by Belinda L. Collins

Standardization issues facing the United States in the global market require development of more effective strategies, both domestic and international. The World Trade Organization (WTO) commitment to harmonized international standards is uniquely difficult for the United States, which relies extensively on numerous private sector standards developers---with active participation by industry, government, consumers, and other interested parties. We have high quality standards which support U.S. technology effectively, but which do not respond adequately to the challenges of the global market. The current U.S. standards system is complex, multifaceted, and comprised of many diverse elements, many of which appear unnecessarily redundant. The lack of central focus and fragmented sector-specific approach is a handicap for the United States in the international standards arena. Much more effective cooperation among government, standards developers, and industry is needed to build effective solutions for supporting international standards, and to work with international partners to develop standards which meet the global challenges. This chapter identifies some of the problems and offers some solutions for NIST to help strengthen the U.S. presence in the international standards arena.

Chapter VI: "Develop Conformity Assessment Processes," by James L. Cigler

The rapidity with which technological change is occurring in many industrial areas, combined with escalating globalization of U.S. trade, has increased the need to standardize various aspects of the marketplace and to ensure conformance to standards. Conformity assessment is defined as "any activity concerned with determining directly or indirectly that relevant requirements are fulfilled." Three activities collectively make up what is generally referred to as conformity assessment: product certification (includes sampling and inspection); laboratory accreditation of testing and calibration laboratories; and quality system registration. Conformity assessment has a great impact on trade in both domestic and international markets as reflected in international standards and their development, recognition of competent parties to perform conformity assessment activities, and the ultimate goal of ensuring the quality of consumer and safety needs. Conformity assessment activities are a vital link among normative standards, product requirements, and the products themselves. NIST plays major role in these areas as the national measurement laboratory and measurement research institute.

Chapter VII: "Support U.S. Foreign Policy Objectives," by B. Stephen Carpenter

International science and technology (S&T) cooperation is often an integral part of U.S. foreign policy, particularly with countries where there are significant cultural differences and where trade and economic issues are challenging. S&T cooperation can enhance vital linkages that promote goodwill and can often advance a specific U.S. policy objective with a specific country. S&T is an effective means through which the United States can encourage political changes and economic growth in a country or region and it is in our interest to take advantage of our position as a leader in S&T and to use it effectively to promote U.S. interests abroad. And, as described in other chapters of this report, such S&T cooperation contributes directly to the NIST mission. NIST researchers have developed collaborative relationships that have created a significant stimulus for new measurement capability and new standards, and have made it easier to adopt a consistent measurement and standards system.

I. Economic Roles of Standards in International Trade

Gregory Tassey*

Abstract

U.S. firms have substantial concerns about the economic effects of standards because this form of infrastructure can either facilitate or inhibit technological innovation, market entry and opportunities for both exporting and importing. The type of standard that affects an element or attribute of a product can enable large markets to evolve and ensure that investments in the R&D and production capability for products that are complementary to the standardized product will benefit from a single, unified market. U.S. firms exporting into foreign markets want to extend these domestic efficiency gains by conforming to the same product-element standard or at least incurring minimal costs of adaptation to a different standard. A second type of standard affects the environment in which the product is developed, produced, and marketed. Such standards provide information (test methods), ensure performance (quality specifications), or enable compatibility or interoperability among several products making up a product or service system (interface standards). Thus, both types of standards offer major opportunities for U.S. business. Alternatively, standards can evolve into multiple and inefficient forms, thereby acting as barriers to domestic growth and international trade to the detriment of U.S. economic welfare.

Background

The internationalization of markets is a rapidly evolving phenomenon, resulting from both the larger number of economies participating in world markets and attempts by all nations to increase their economic well being through trade. Standardization is an increasingly important infrastructure supporting this expanding trade. Several reasons explain this trend. One is simply the increased volume and diversity of trade, which therefore involves more products and services and the associated standards (roughly $150 billion in U.S. exports are affected by standards).[1] Another reason is the greater complexity of both products and services---due primarily to their increased technological content.

Trends in Trade

The globalization of markets means both opportunities for and threats to domestic economic growth. In recent decades, the ability of an increasing number of nations to first acquire technology, develop it themselves, and then become consumers of technology-intensive products has greatly expanded the number of markets in which U.S. companies face both significant opportunity and competition.

In the past 25 years, U.S. Gross Domestic Product (GDP) has increased by 618 percent, but exports have grown by 1800 percent (and thus from 4 percent of GDP in 1970 to 11 percent in 1995). Unfortunately, imports have grown even faster, resulting in a persistent trade deficit. In fact, because of this deficit, trade is a net drain on GDP. Without the trade deficit, U.S. GDP would have been $102.3 billion higher in 1995.

While many analysts point to the emergence of developing economies as a growing source of competition for U.S. domestic businesses, the fact is that these economies have a rapidly increasing demand for products and services from industrialized nations. International Monetary Fund data show that the developing countries' trade

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*Gregory Tassey is Senior Economist, National Institute of Standards and Technology.

[1]Department of Commerce, *Toward the Next American Century: A U.S. Strategic Response to Foreign Competitive Practices*, October, 1996. This figure represents roughly 20 percent of total U.S. exports.

balance with industrial countries, after remaining pretty much in balance in the 1980's, has become increasingly negative in the 1990's, reaching a deficit of $153 billion in 1995. This rapid growth in demand for industrialized nations' products and services has helped fuel a rapid growth in U.S. exports---but not at a sufficient rate to bring U.S. trade into balance.

In fact, in the area of trade where industrialized nations should excel---technology-based products and services---the United States' recent performance has not been encouraging. The broadly defined U.S. trade position for technology-dependent manufacturing has been in persistent decline in the 1990's. The more narrowly defined trade balance based on high-tech *product* fields is still positive, but the balance calculated on the somewhat broader *industry* basis has been negative since 1994. And, of course, the overall trade balance has been negative for two decades, in spite of widespread restructuring, downsizing, increased emphasis on technology, and so forth.

The U.S. position in services is much better. In 1995, exports of services reached $208 billion with a substantial trade surplus of $81 billion. However, trade in services seems to be increasingly based on or driven by advanced information technologies, in which other nations are rapidly expanding their investments. These nations can therefore be expected to become more competitive in the related services.

The above trends, even the positive ones, should be the subject of serious concern because overall export growth is due in large part to a dramatic depreciation of the U.S. dollar against the currencies of our major trading partners (48 percent against the German mark and 53 percent against the Japanese yen in the period 1985-95). The fact that this depreciation has stopped and reversed direction somewhat implies that the U.S. trade deficit may increase, rather than decline, in the future.

A depreciating currency is not a viable long-term solution to trade deficits. A sustainable long-run solution to the trade deficit is a major expansion in exports of technology-based goods and services, which are somewhat less price sensitive than commodity items and which have relatively less competition. In other words, a promising strategy is investment in competitive technology-based industries supported by the appropriate technical infrastructure, including U.S.-compatible international standards and compatible assessment practices.

Employment Effects of Trade

About 8 million U.S. workers are employed in export-related jobs. A recent study by the Economics and Statistics Administration (ESA) using time series data covering as much as 15 years found that exports by high-technology manufacturing industries directly and indirectly supported 2.3 million U.S. jobs in 1992, and that the workers in those jobs were paid higher wages than in most other industries. Equally important, exports in high-technology manufacturing industries were found to leverage jobs in other industries to a much greater degree than in the reverse case.

For example, 40 percent of the 2.3 million economy-wide jobs supported by high technology manufacturing exports were in the service sector. In contrast, high-technology industries are far more dependent on their own industries' exports than on other (non-manufacturing) industries' exports. Here, ESA data show that in 1992, of the total 1.2 million jobs in high technology manufacturing industries supported by all types of goods and service exports, 87 percent (1.0 million jobs) were supported by their own industries' exports. Such data not only indicate the importance of technologically advanced manufacturing for economic growth but also demonstrate the leveraging effect of this area of manufacturing on the service sector.

A second study by ESA, using data at the level of the individual manufacturing plant, shows that employment grew 36 percentage points faster in plants that used advanced technology and exported, compared with plants that used little technology and did not export. Technology and exports both contributed independently to employment growth. High-tech non-exporters increased employment by 13 percentage points more than comparable (adjusted for plant size and industry) low-tech non-exporting plants, while low-tech exporters increased employment by 21 percentage points more than high-tech non-exporters.

Similarly, high-tech exporting plants paid wages that were 16 percentage points greater than the baseline low-tech non-exporting plants. Again, both high-tech non-exporting and low-tech exporting plants paid higher wage rates, 7 and 8 percentage points, respectively, when compared to the baseline group of plants.

Barriers to Export Growth

For centuries, tariff and non-tariff barriers to trade have been erected to protect domestic industries from foreign competition. Non-tariff barriers can be blatant when they specify product attributes that favor the domestic industry's version of a product or service, or subtle when they require testing or certification of foreign products or licensing of service operations that are excessive or simply deliberately delayed. Even though "economic recovery" or "infant-industry" arguments are often devised by economists to rationalize these policies, such barriers are basically politically-motivated and therefore must be dealt with primarily through a politically oriented process of negotiation. The Trans-Atlantic Business Dialogue, involving over 100 CEOs from North America and Europe, stated at a 1995 meeting in Seville, Spain that standards and conformity assessment practices are the greatest barriers to their firms' export growth.

Because of the complexity of technology-based products and services, such non-tariff barriers can themselves be complex and thus difficult to identify and negotiate away. In addition, such barriers can have large negative effects because of the importance of lead time in deciding whether or not to invest in a new technology. Estimating commercialization opportunities and planning domestic and foreign market penetration strategies can be thwarted by the lack of timely assurance of open markets in other countries, which can therefore negatively affect these investment decisions.

Functions of Standards in a Technology-Based Economy

The role or function of standards has expanded since the industrial revolution when factories achieved economies of scale through reduced variety and users saved enormous maintenance costs through interchangeable parts. Today, standardization forms a pervasive infrastructure that affects the technology-based economy in many important ways and hence imparts significant economic effects. In fact, whereas the traditional economic role of variety reduction can restrict product choice in exchange for the cost reductions from economies of scale, some modern functions of standards facilitate technological innovation and product choice.

The multiple functions (described below) that are now played by standards, coupled with increased pervasiveness of technology and shorter technology life cycles, combine to require faster responses from the standards development process. Critical emerging technologies with impacts on large numbers of industries have both a technical complexity and a "systems" character which raise the economic role of standards to a new, higher level of importance.

The costs of not dealing with these factors in a modern economy have not been lost on government policy makers around the world. In fact, more and more resources are being devoted to ensuring that standards are promulgated in order to leverage a domestic industry's "enabling" technologies and to provide the interfaces for these technologies with other elements of advanced technology-based product or service systems. The content of these standards and the timing of their implementation are having significant impacts on industry behavior and structure---trends which will have lasting *relative* impacts on the competitiveness of the world's industrialized economies.[2]

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[2] All industrialized nations are increasingly conscious of the impacts of standards on technology-based markets. For example, Japan is into its Seventh Industrial Standardization Long-Range Plan. In a 1990 position paper providing recommendations for this plan, the Japanese Industrial Standards Committee stated that "it is important to maintain contact with research and development activities in order to standardize measurement, testing and evaluation methods and to ensure compatibility of products by forward-looking standardization. Thus, standardization can proceed in parallel with research and development. In doing so, standardization itself can become the object of R&D, especially in testing and evaluation methods."

The analysis of these roles in terms of their interaction with corporate strategy and global economic trends is complicated and thus may frustrate the casual observer. Technologies, market structures, and business strategies all depend upon or interact with standards, and thus make this type of infrastructure a complex element of technology-based competition. Ignoring this complexity, however, guarantees poor strategy formulation and poor infrastructure support for standards.

The economic functions of standards in domestic and foreign markets can be effectively analyzed by placing them in four categories:[3]

Quality/Reliability: standards are developed to specify an acceptable level of product or service quality/reliability along one or more dimensions such as performance levels, performance variation, service lifetime, efficiency, safety, and environmental impact;

Information: standards provide evaluated scientific and engineering information in the form of publications, electronic data bases, terminology, and test and measurement methods for evaluating and quantifying product attributes;

***Compatibility/Interoperability*:** standards specify properties that a product must have in order to work (physically or functionally) with a complementary product or other components within a "system"; and,

Variety Reduction: standards limit a product to a certain range or number of characteristics such as size or quality levels.

Types of Standards

These functions tend to be grouped to a significant extent by type of standard. One type affects a particular element of a product or service. Examples are the architecture of a microprocessor or the operating system of a personal computer. These "product-element" standards primarily reduce variety and are often set through the competitive dynamics of the marketplace. They are therefore de facto rather than promulgated standards.

The second type of standards primarily includes those that affect the *environment* of a product or service. Examples of these "non-product" standards are:

- test and measurement standards that provide information about the performance of a product (such as signal strength loss in an optical fiber)

- interface standards that specify the physical and/or functional interactions between two components or a larger product system (such as the physical specifications and data format requirements necessary for computer and printer to work together)

Non-product standards providing one of the four basic functions listed above are frequently related to other standards in hierarchical structures. These hierarchies result from the need to ground or validate *industry* standards by tracing their content back to more *fundamental* or *basic* standards, which are derived from scientific laws or

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[3] Source: G. Tassey, *The Economics of R&D Policy*. Westport, CN: Quorum Books (forthcoming)

principles. A few basic standards can support large numbers of industry standards, but basic standards are not easily transported or used by industry. Thus, as indicated in Figure 1, such standards are converted into working and transfer standards which transfer the standardized information to industry. Large numbers of industry standards are based on (traced back to) the basic standards. Most industry standards are methods, procedural, or normative.[4]

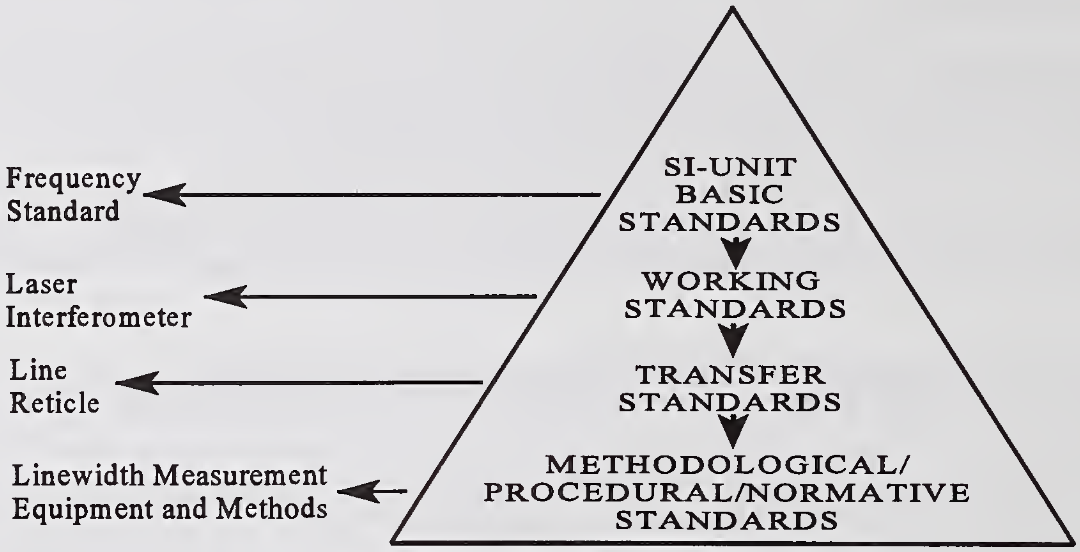

Figure 1. Path to an Industry Standard

Source: G. Tassey, *The Economics of R&D Policy*. Westport, CN: Quorum Books (forthcoming)

Figure 1 illustrates how basic standards may be utilized to develop the infratechnologies upon which semiconductor industry standards are based. The production of semiconductor components is a highly demanding process. The densities of today's circuits are such that each conducting path ("line") on a chip is a small fraction of the width of a human hair. These widths must be consistent with respect to design specifications to avoid thermal, electrical, and other problems.[5] The semiconductor producer therefore needs to be able to measure the widths of circuit lines that make up a "chip." Particularly important are line widths on the "masks" which are used to inscribe the multiple layers of circuit patterns on the chip itself. Such masks are used to make tens of thousands of chips. Their quality greatly affects performance of the chips produced and hence a semiconductor manufacturer's production yield.

[4] A normative standard is one in which a particular value (size, performance, quality, design) is selected from a range of alternative values.

[5] Line width measurement is just one of many infra technologies that a competitive semiconductor industry must utilize. For example, current state-of-the-art chips consist of multiple layers of circuits. The circuits in each layer must be connected to adjoining layers. Accomplishing this very difficult manufacturing step requires a precise alignment of the mask for each layer. Until recently, the alignment process required multimillion dollar optical equipment. NIST, however, developed a procedure that allows semiconductor manufacturers to ensure proper alignment of successive layers of an integrated circuit with a precision better than 10 nm. This represents a more than fivefold improvement over current alignment calibration methods and is much less expensive. The cumulative economic impact of such advances in infra technologies is substantial and can greatly affect price and hence competitive position for the domestic industry.

The line width measurement equipment must be calibrated against a physical standard, which has a pattern of lines whose thicknesses and spacings have been determined to a specified level of accuracy. This determination is done by an authoritative source, such as NIST in the United States. The physical or "transfer" standard used by industry must be easily transportable (a reticle in the above example) in order to ensure widespread and accurate transfer of the infratechnology.

The information transferred by a physical standard is itself determined or certified by a so-called "working" standard, which is laboratory-based and more accurate but not readily transferable. In this example, the working standard is a laser interferometer which measures and certifies the physical dimensions of the line reticle prior to transfer to industry. Finally, the laser interferometer is itself dependent for calibration on a "basic" standard for length.[6]

Line-width measurement standards are just one of many non-product standards that affect a single industry. The four basic functions of standards are all represented in this type of standardization in a single industry such as semiconductors. Many standards, such as line-width measurement, provide information, while others affect variety reduction, quality/reliability or compatibility/interoperability. The collective economic impact of these standards is greatly magnified when an entire supply chain is considered. Semiconductors are a component of computers and communications equipment, which, in turn, comprise a communications network. Each level in the supply chain has an elaborate infrastructure of standards.[7]

Multiple standards of both types frequently exist in a single industry or market. Moreover, an economy's structure consists of sets of vertically and horizontally integrated markets or "supply chains." When an entire "supply chain" is considered (the linkage of markets for raw materials, components made from those materials, equipment made from components, and finally systems of equipment or services based on these elements), the number and variety of standards involved is typically substantial and so therefore is the cumulative economic impact.

Government Research in Support of Standards

Product element standards are frequently set through the competitive dynamics of the marketplace. Non-product standards, however, are typically based on infra structural technologies called "infra technologies."[8] Infra technologies are "tools" that make the R&D, production, and market penetration stages of economic activity more efficient. Examples of these tools include measurement and test methods, standard calibration protocols and reference materials, qualified science and engineering data bases, and even entire process models or procedures. Infra technologies achieve economic efficiency in two basic ways: (1) they increase static efficiency; that is, they permit increased levels of productivity or quality; and (2) they increase dynamic efficiency by decreasing learning times through provision of more and accurate information in real time (as opposed to after-the-fact testing), which allows companies in the early phases of a product life cycle to complete R&D or reach target production yields faster.

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[6] The wavelength of light is used as the basic standard of length. The inverse of the wavelength is *frequency*, and the length standard is actually derived from a frequency standard.

[7] In communication networks, for example, there are published standards and interface protocols that allow hardware components and software from many vendors to operate as a single product or as a system of products (i.e., a network). To achieve efficient or "seamless" integration, the standards and protocols define what rules hardware components must adhere to in order to exchange signals between applications software and operating systems at different levels in the network.

[8] G. Tassey, "Infra technologies and Economic Growth" in M. Teubal *et al* (editors), *Technology Infrastructure Policy: An International Perspective.* Norwell, MA: Kluwer, 1996.

However, industry under invests in infra technologies because (1) these tools often derive from a different generic technology base than the core technology which industry draws upon to develop its products and processes, (2) they are used simultaneously by many firms (i.e., as industry standards), which gives them an infrastructure character, and (3) infra technologies often cannot be embodied in products and processes (i.e., they are *techniques*), which makes capturing the benefits from investment in them more difficult. The resulting under investment creates a need for government support.

Alternatively, reasons for under investment in infra technologies (and hence in the technical basis for non-product standards) can be grouped under two major categories:

- ***appropriability problem.*** The economic value of an infra technology (e.g., a measurement or test method) increases the more widely it is used. Adoption as the basis for a standard implies widespread use, including among competing firms. This requirement of common use makes standards a type of infrastructure, which, in turn, means that underlying infra technology is jointly owned by the users of the standard. Hence, full or even substantial appropriation of the economic benefits by the firm developing an infra technology is unlikely.

- ***research efficiency problem.*** Even when individual firms have sufficient need or when they perceive sufficient appropriability of the research results to undertake infra technology research, under investment frequently still occurs because the scientific or generic technology basis for the infra technology is different from that required to develop and produce the firm's products. The result of this mismatch is inefficient infra technology R&D by individual firms.

Thus, even though the aggregate benefits to the industry or group of industries from infra technologies and the standards based on them are high, the rate of return to an individual firm is often not high enough to rationalize the required investment.

Such under investment can sometimes be addressed adequately through collaborative research by the benefiting firms. However, even though this approach may expand the total amount spent on infra technology research, appropriability and research efficiency problems remain. The persistent existence of "market failures" (under investment) therefore requires government research, such as that provided in the United States by the National Institute of Standards and Technology (NIST). NIST responds with a research program conducted either entirely in its laboratories with subsequent transfer either directly to industry or to a standards setting organization or by a collaborative research arrangement with several industry partners.

NIST research programs, often undertaken in collaboration with industry, develop a wide range of infra technologies for U.S.-based firms, including primary (basic physical and chemical) standards, manufacturing process models, advanced measurement methods for specific technologies/industries, technical databases, product performance tests, interoperability protocols, calibrations, and quality assurance techniques.[9] Economic research has shown that infra technology research produces social rates of return at least as high as for private-sector investment in technology.

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[9] NIST has a number of bilateral research arrangements with industry partners and 15 consortia (two or more companies). These partnerships are structured by use of a Cooperative Research and Development Agreement (CRADA).

Internationalization of Standards

Exporting offers the potential to increase the returns on investment in various economic assets (technology, plant and equipment, training) over what is possible within the domestic market alone. Such expansion is especially important in a global market environment because imports take away a portion of potential domestic sales from a product group in which a domestic firm has made an investment. This loss can be made up through exports of the products in that group in which the domestic firm has a comparative advantage.

Along with other factors, successful exporting requires (1) standardization of certain product attributes, and (2) conformance to these standards that is both timely and cost-effective relative to competition in foreign markets. The availability of harmonized standards for international markets affects the ability of U.S. firms to use the same production line for domestic and export markets and thereby determines the ability of these firms to realize economies of scale in production. For example, consumer electronic devices and household appliances must be adapted for different power supplies in the United States and Europe – 110 volts/60 Hz and 220 volts/50 Hz, respectively, and such economies are therefore not realized.

Automobile production lines must be switched between right-hand and left-hand drive cars for the United Kingdom and continental Europe or altered because safety requirements and environmental emission standards vary between the United States and Europe. And, driver-side designation is just one of a number of cases of non-harmonization in this one industry. Design specifications affected by research and development, manufacturing process, and other product-specific standards exist and raise costs of international trade. Other examples of such design standards that differ between the United States and Europe include windshield wipers, safety belts, steering control system impact protection, and seating systems. Different testing and certification protocols (for example, in pharmaceuticals) also may affect product design and hence commercialization decisions and production requirements.

All national economies suffer to varying degrees from barriers to free trade, including those from ineffective standards or from the deliberate use of standards to block imports. A statement accompanying release of a 1996 report by the National Research Council and two German research institutes on high-tech trade concluded that

> *"More and more countries are turning to restrictive trade measures and subsidies to develop the high-technology industries they believe will provide faster economic growth, higher wages, and greater national autonomy. In the recent past, international trade disputes have erupted over semiconductors, large commercial aircraft, and other technology-intensive products, in part because established producers believed foreign governments were unfairly supporting their competitors."*
>
> The report also says that *"unless sustained efforts are made to open high-tech markets and encourage balanced cooperation, trade conflicts like the disputes on semiconductors and Airbus will occur again. Renewed conflict may be fueled by the rapid entry of newly industrializing countries into the high-stakes, high-tech global marketplace. These disputes could significantly damage not only the multilateral trading system but also the tradition of international cooperation on scientific research and the prospects for collaborating in the development of new technologies."*

The economic stakes are truly large. A 1995 National Research Council report estimates that the removal of all quantitative trade barriers (tariffs and quotas) for U.S. manufacturing industries such as textiles, apparel, autos, and steel would result in 0.5 percent increase in U.S. national income ($25-$29 billion), and that the reduction in economic growth from non-tariff barriers in these industries is equivalent to a 49 percent tariff.[10]

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[10] National Research Council, Conformity Assessment and Trade, 1995, p. 107.

In addition, the relentless increase in the importance of technology means that the two generic types of standards described above can arise within individual national economies as part of the competitive dynamics of technology-based markets coupled with a domestically focused government infrastructure role. Problems arise when the industries in each of two nations attempt to export into a third market, presenting buyers with multiple standards. Further complicating such situations is the increasing tendency for alternative standards to arise around multinational groups of firms, linked through joint ventures.

Recognition of these efficiency issues with respect to standards and trade has led to greater efforts to "harmonize" existing national standards and to develop new ones at the international level. However, the processes of harmonization and cooperative development of new standards are often thwarted by conflicting economic growth strategies in participating nations.

Thus, even though general agreement exists that effective standardization enhances economies of scale in production, results in savings through reduced transaction costs, and, in many cases, provides access to products and services in other countries that would otherwise not be available, individual nations or alliances of firms from several nations often are unable either to agree on standards or to develop the technical basis for standards. Moreover, industry alliances and nations often disagree over the appropriate methods for assessment of conformance to standards (which really should be viewed as an integral part of the complete standard). Therefore, international standards development and conformity assessment often require the assistance of national governments working through international standards organizations.

Even when the domestic economy's need for standardization has been met by government-industry cooperation in developing the technical basis for a standard, other nations frequently have gone through a similar and simultaneous process, with the result that multiple versions of the same generic standard arise. A solution often requires government participation to help industries in several nations agree on rationalization (harmonization) of the several competing standards. This participation typically includes critical technical input from respected third parties (government laboratories or institutes) before final decision making by an international standards-setting process.

In summary, U.S. firms want (1) their production lines in the United States to be capable of efficiently producing products for export, as well as for domestic markets (economies of scale), and (2) for export markets where different product attributes are required, to be able to conform to these different market demands cost effectively (economies of scope).

International Standardization and the Government Role

Because the U.S. domestic market is large with consequent sufficient internal competition in most industries, the U.S. economic philosophy has been to allow the competitive dynamics of the marketplace to set product-element standards. Issues of unfair advantage in related markets for the firm whose technology eventually wins out as the industry standard are raised periodically. In other cases, several competing "local" standards often coexist for some time, resulting in complaints of inefficiency. Still, the rapid growth of many such domestic markets and the competitive success of U.S. firms in exporting argues for caution with respect to government intervention, especially in product-element standardization.

However, to the extent that monopolistic control of a standard or the existence of multiple standards create economic inefficiency, the globalization of technology-based competition can accentuate these problems. An increasing number of national economies is now capable of competing for the dominant product-element standard in technology-based industries. National governments often support the domestic industry's standard over alternatives. Moreover, multinational alliances of firms now pursue their version of a product-element standard in emerging technology-based markets. Thus, multiple standards can arise and persist for some time. In such cases, multilateral efforts should be undertaken to at least harmonize among these competing standards, if not to select one as a single international standard.

Many infra technologies also become the basis for international standards. In these situations, NIST extends its research and domestic technology transfer roles to provide technical assistance to the international standards setting process. To better perform all of these roles, NIST is increasing economic analysis and strategic planning to understand the complex economic impacts of multiple standards within individual U.S. industries and the under investment phenomena that create demands for government infrastructure support.

Example of the Economic Impacts of Multiple Standards: Numerically-Controlled Machine Tools

The interfaces among individual components which make up advanced manufacturing systems, such as numerically controlled (NC) machine tools, have a number of important economic impacts that affect rates of economic growth and competitive position in international markets.

Standardization of these interfaces allows multiple proprietary component designs to coexist, with the important economic consequence being a substantial increase in competition at the component level and therefore greater design variety and price advantages for buyers. In effect, component competitors can innovate on "either side" of the interface, while the consumer of the system of components can select the particular vendors' components that best meet system design requirements. Because a product system (in this case, the machine tool) has a number of components with multiple interfaces, several interface standards are needed to, in effect, "modularize" the product and thereby allow custom design and prevent obsolescence at the system level.

However, the need for interface standards is not the entire story. The technical difficulty and hence the cost of constructing efficient interface standards increases substantially when *all* elements of the products on either side of the interface are proprietary. The frequent solution to this problem is to standardize or "open" a product element or attribute.

In the above example of machine tools, making the architecture of the machine tool controller "open" creates the conditions for substantial increases in overall efficiency, including increased incentives for innovation. An open architecture for machine tool controllers greatly facilitates the development of complementary hardware and software components by allowing all vendors to design their components to a global standard interface determined by a single architecture. As opposed to multiple interfaces for multiple architectures, the existence of a single standard interface unifies and thereby enlarges the prospective markets for components. Subsequent technological improvements to the system of components are facilitated as well. Without an open architecture, controller upgrades would likely not be accomplished without costly re-engineering of interfacing components such as sensors.

These interface standards increase the efficiency of systems integration by substantially reducing the engineering costs of physically and functionally joining components from different manufacturers to form an optimal system for a particular user, and by allowing efficient substitution of more advanced components as they become available over time, thereby greatly reducing the risk of obsolescence of the entire system. Product-element standards, such as open architectures, create a single, larger market, thereby providing greater incentive for innovation.

Moreover, both initial purchase and maintenance costs are reduced because standardization increases competition among suppliers, reduces lead times for procuring components, and reduces inventory requirements. Training costs are also reduced because the operator interface remains more constant as technology upgrades are made. In conclusion, interface standards, such as those affecting systems technologies such as factory automation, are essential for significant market penetration.

Example: International Standardization: Semiconductor Wafer Dimension Standards

In semiconductor manufacturing, the number of chips obtainable from a single silicon wafer has increased as the size of the wafer has grown. Because of the many times a wafer must be moved during processing (over 300), much of the production cost results from required delicate and precise handling as well as the down time (from actual processing) while the wafer is being moved. Larger wafers, by yielding more chips per wafer and increasing the time actually devoted to processing, result in proportionately less materials and process costs (previous transitions to larger wafer sizes have provided cost reductions greater than 20 percent per unit area).[11]

The current transition in wafer size is from 200 mm to 300 mm. Unlike previous transitions that simply raised the minimum efficient scale and hence minimum unit cost of a chip manufacturing plant, the current changeover has some different potential economic impacts. In particular, the larger wafers may actually permit reversal of the trend of increasing capital intensity of production. Larger wafers with proportionately greater yields may make smaller production runs cost-effective and allow both more and smaller firms to operate production lines efficiently. Such a development could at least partially reverse the trend away from captive production and allow semi-custom chip designers to produce their own chips once again.

Accomplishing this transition and the subsequent economic benefits will require a complex and integrated standards development process. Because of the high degree of precision required to manufacture incredibly dense integrated circuits (IC), dimensional standards are required for the basic wafer, plus the transport cassette, and other equipment that physically interact with the wafer. Interface standards must be developed for the interactions between processing tools and wafer transport and positioning equipment. Communications interface standards are needed to permit different vendors' equipment to interact functionally as a production system.

Past transitions with the associated standards have been achieved by a single dominant IC manufacturer providing leadership in defining wafer specifications. The number of equipment suppliers involved was usually limited to the IC leader's preferred vendor list. While such leadership by a single manufacturer might seem desirable from the point of view of that firm's competitive position, imitation by rivals has been increasingly rapid with each transition, meaning that the small advantage gained is overwhelmed by the costs incurred in developing and verifying the complex set of complementary standards that interface with the main standard (the 300 mm wafer size).

The huge potential cost of 300 mm fabrication plants and the consequent financial risk was finally perceived as being too great for individual IC manufacturers to either undertake the standard development effort alone or to risk their future competitive position to a "trickle-down" standardization process. As a result, the 300 mm standards are being developed through an international organization made up of 13 IC companies from three continents and six countries, including six companies from the United States, three from Korea, and one each from Taiwan, the Netherlands, Germany, and France. The standards development process began in 1992 and has increased steadily in intensity. The consortium of IC companies has allocated $26 million for an 18-month effort in 1996-1997 to advance the standardization process. Ten Japanese companies have declined to participate in this multinational process and have formed a separate consortium to develop the required set of standards. They have also apparently allocated $370 million over 5 years to both standards development and to process technology research.

In summary, this example indicates how the approach to standardization can evolve in the face of the high costs involved in developing sets of related standards focused around a lead standard. It also demonstrates, however, how the struggle for competitive position might result in multiple standards.

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[11] R. Horwath and G. Lee, "300 mm: Not 'If' but 'When' and 'How'," *Channel*, June-July, 1996.

Conclusion

Standards of both types---product and non-product---can greatly affect the overall efficiency and hence competitive position of groups of related industries. Collectively, such industry groups provide substantial value added (contribution to GDP) and therefore are important to national economic welfare. Increasingly, large portions of this value added derive from exports, and therefore the roles and impacts of standards on design, production, and finally on trade are more critical than in the past.

II. Collaborate in Advancing Measurement Science

Katharine B. Gebbie*

Abstract

Metrology, part of this country's "hidden infrastructure," plays a critical role in the modern world, especially the fields of medicine, agriculture, and manufacturing. Any country's measurement infrastructure is ultimately limited by the accuracy and stability of its primary standards. The International Bureau of Weights and Measures (BIPM) establishes the basic standards and scales of the principal physical quantities (such as the meter, kilogram, and second). Since BIPM measurement technology is the basis for international standards, NIST's current leadership role in that organization is important for U.S. trade interests---losses in the U.S. scientific leadership in primary standards translate downstream into lost opportunities in U.S. production of technology-based products and services, and in their export. Yet NIST is not presently competitive with European national laboratories in such areas as realizing the basic unit of time or in frequency-based length standards. U.S. leadership in international measurement technology is credible only to the extent that it is based on the best technical judgement available from whatever source. Accordingly, NIST collaborates with its foreign counterparts on a broad range of projects, and benefits from the cross-fertilization afforded by the over 300 visiting foreign scientists at NIST, as well as multi-country use of unique national measurement facilities. A list of priority metrology research projects needed for NIST to regain wider international leadership in metrology and to meet industry requirements is provided.

Background

The National Bureau of Standards, now NIST, was created to assist U.S. industry with uniform and accurate measurements to strengthen the nation's economy and to compete successfully in international markets. From the beginning, NIST's managers and congressional overseers have recognized that the fundamental triad of standards, measurements, and data can be addressed only in the context of an institution steeped in the scientific disciplines and actively participating in research in those disciplines. Our ability to lead the world---or even to be a major player---in establishing uniform and accurate measurements, normative standards, and conformity assurance (as advocated in subsequent chapters of this report) depends in large measure on the breadth, vigor, and excellence of our research programs. Our leadership in international measurement metrology is credible only to the extent that it is based on the best technical judgment available. And because a scientific effort of high vitality and creativity is characterized by a free flowing atmosphere of ideas and people, we must work closely with scientists throughout the world, collaborating on basic research, participating in workshops, comparing our standards, and sharing our facilities.

In the remainder of this chapter, we discuss the role of measurement science in our economy and NIST's participation in international measurement science through the International Bureau of Weights and Measures, through collaboration with scientists throughout the world, and through the use of international facilities. We then discuss the continuing need for research in metrology, and finally we outline the efforts required to attain and maintain a wider leadership role in the international arena.

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Critical Role of Metrology

Metrology, the science of measurement, is part of the hidden infrastructure of the modern world, which registers hardly at all upon the public consciousness. Yet measurements have a direct influence on our lives in many areas including health care, information technology, semiconductor electronics, construction, manufactured products, and environmental technologies. Legal metrology is having an increasing impact on world trade. Measurements are critical to our nation's ability to compete in the world market.

For example, metrology is part of medical diagnostics, as in the measurement of blood cholesterol level, and part of medical therapy, as in the measurement of x-ray or gamma-ray dose for the treatment of some forms of cancer. Here, permissible measurement uncertainties must be small enough so that they are of no clinical significance, usually a few percent. Without the efforts that are already made to ensure accuracies of a few percent in radiotherapy, for example, overdoses or under doses of a factor of ten would be common. Reliability is of the utmost importance, for errors can and have been known to kill. Even small errors are enough to confound clinical trials that gather statistical evidence.

Metrology affects the quality of the food and drink that we consume. In agriculture, in the testing of food products, and in programs to protect the environment, measurement is becoming increasingly important in providing the basis for, and the means of verifying conformity to, a wide range of legislation. Some of this is related to ensuring that pesticides, heavy-metal residues, and bacteria in food are kept at safe levels; others are related to labeling, packaging, and assuring the nutritional content of food stuffs.

Metrology affects manufacturing industries. About half of all manufactured products are discrete items, such as aircraft, motor vehicles, and computers, together with their component parts. The other half comprises goods manufactured in bulk. In the United States, the value of such discrete items exceeds $600 billion---more than 10 percent of the gross domestic product. Of this, about $240 billion is generated by the automotive industries, more than $100 billion by aerospace, another $100 billion in instrumentation, control, and computers, and the rest by diverse industries. For most of these products, their performance and perceived quality, and hence their commercial success, is determined by how well they are made---sometimes in quite unexpected ways.

An example of how quality and commercial success can be linked to manufacturing precision appeared in the early 1980's. Opening the doors of Japanese cars needed a force only one third that required for U.S. cars. This difference could be attributed to the dimensional tolerance of 1 Mm on doors and door assemblies specified for Japanese cars compared with 2 Mm for U.S. cars. Ease in opening the door appeared to be an important factor in the customer's perceived quality of the whole product. In this case, the economic consequences of this difference in the precision of manufacture and in perception of quality were dire for the U.S. automotive industry.

Engineering tolerances, i.e., the amounts by which dimensions are permitted to depart from nominal values, have decreased in practically all industrial production by a factor of 3 every 10 years since 1960. The result is that production engineers in the large-scale manufacture of automotive and electronic products are now required to work at tolerances previously attempted only in fine, small-scale work. For example, the pistons of car engines are now being made to a tolerance of about 7 Mm, roughly that used for the components of mechanical wrist watches.

There are basic motivations for this improvement of precision in manufacturing industries over the past 30 years. The first is that in traditional mechanical engineering, improvements in performance and reliability have been possible only through improved precision in manufacture. The second is that many of the new technologies, often the practical applications of recent discoveries in physics, simply do not work at all unless high precision manufacturing is available.

Examples are found in the electro-optic industries using lasers, fiber-optics and video disks, in the manufacture of large-scale integrated circuits, and in the production of navigation systems using signals from atomic clocks on satellites. Dimensional tolerances of 0.1 Mm are required. And if the rate of information flow over data networks and other telecommunications systems is to increase, we need to have accurate, internationally coordinated time scales. Synchronization tolerances of a few nanoseconds are required. Such fine tolerances in actual manufacturing and use require an accurate measurement capability at an even finer level.

The International Bureau of Weights and Measures

There is no more fundamental aspect to NIST's international metrology activities than its role on behalf of the United States under the treaty known as the *Convention of the Meter*, which founded in 1875 the International Bureau of Weights and Measures (BIPM).

The primary mission of the BIPM is to establish the basic standards and scales of the principal physical quantities (meter, kilogram, second, ampere, volt. etc.), to maintain international prototypes, to carry out comparisons of national and international standards, to assure coordination of the corresponding techniques of measurement, and to carry out and coordinate determinations of fundamental physical constants. This mission is becoming increasingly important for three reasons.

First, international trade, the manufacture of high technology products, scientific research, the protection of the environment, and many aspects of health and safety, are increasingly dependent on accurate measurements and require easy access to a stable, worldwide system of measurement. This is provided by the International System of Units, maintained by the ensemble of national metrology laboratories working together with the BIPM under the auspices of the *Convention of the Meter*.

Second, the increasing requirement for the strict application of performance criteria in the field of quality certification and laboratory accreditation assumes the existence of the worldwide measurement system maintained under the *Convention of the Meter*. For member nations of the *Convention*, the activities of the BIPM are an important and highly effective way of assuring this basis for measurement.

Third, the BIPM represents an efficient and cost-effective way of assuring the multiplicity of links necessary to demonstrate the equivalence of measurement standards maintained by the many national laboratories and to provide international traceability. At the same time, it provides certain unique and essential services such as the world's time scale and the calibration of mass standards in terms of the international prototype of the kilogram. Through its calibration services, the BIPM provides an essential link to world metrology for certain metrological services of member nations of the *Convention of the Meter*.

Under the terms of the *Convention*, the BIPM operates under the exclusive supervision of the Comité International des Poids et Mesures (CIPM), which itself comes under the authority of the Conférence Générale des Poids et Mesures (CGPM). The CGPM elects the members of the CIPM and brings together periodically representatives of the governments of Member States.

For advice on scientific and technical matters, the CIPM has created Consultative Committees, which bring together the world's experts in each field of metrology. Among the tasks of the Consultative Committees are the detailed consideration of advances in physics that directly influence metrology, the preparation of recommendations for discussion at the CIPM, the instigation of international intercomparisons of standards, and the provision of advice to the CIPM on the scientific work in the laboratories of the BIPM.

The U.S.member on the CIPM historically has been the Director of NIST; the current U.S. member and CIPM Vice President is the Director of NIST's Physics Laboratory. NIST managers and scientists alike are active participants on all nine Consultative Committees. As such, they have a major role in organizing and contributing to international comparisons of the physical standards of measurement. These painstaking activities provide a measure of the precision achieved around the world in realizing the definition of each unit and serve as an essential check on the national scales of each participant. In addition, they often reveal systematic differences related to the different techniques used in realizing the unit. As a result, the citizen who relies upon the measurement system is assured the highest possible accuracy.

The evolution in the definition of length and the NIST role therein illustrate how a fundamental unit has been refined to keep up with changing needs. When NIST was founded, the standard of length was a ruled Platinum-Iridium bar. However, already in 1893, Prof. A. A. Michelson, on leave from the University of Chicago, had visited the BIPM and demonstrated that the wavelength of a pronounced spectral line could serve as a more universal and natural standard. After years of additional international research, and with growing industrial demand for a more precise standard of length, the CGPM redefined the meter in 1960 to be 1,650,763.73 wavelengths of an orange-red line in the ^{86}Kr spectrum. More recently, modern technology, such as lasers and fast electronics, has allowed further improvement. Today, the meter is defined as the distance traveled by light in a vacuum in 1/299,792,458 seconds.

Such differences in definition are not cosmetic. It would have been impossible to build a metrology system for today's micrometer world of semiconductors from a bar of platinum. This is a world given to rulers made of light. Similarly, lasers offer improved accuracy and ease of use in surveying the great distances measured by civil engineers. None of these advances would have occurred without international cooperative research and consensus in metrology. This story is repeated for each and every one of the basic and derived units of measurement widely used in the world today.

Collaborative R&D for Measurements and Standards

NIST is charged with responsibilities that extend beyond uniform and accurate measurements, and its several laboratories engage in research that applies the measurement system and advance engineering into new domains. Space permits but a few illustrative examples to be given here.

NIST collaborates with national laboratories of other countries, including IMGC (Istituto di Metrologia "G. Colonnetti" of Italy), MPA NRW (Materialprufungfant Nordrhein-Westfalen of Germany), and NRLM (National Research Metrology Laboratory of Japan), to unify Rockwell hardness scales. Throughout the world, hardness is the most often specified materials-property test for manufacturing process control, product quality control, and product acceptance. Nevertheless, hardness values obtained in different countries often do not agree within acceptable limits. The differences result in part from the specification of the test method itself, which permits wide variation in the test cycle; efforts in MSEL (NIST's Materials Science and Engineering Laboratory) focus on minimizing these differences in practice. Research in MEL (NIST's Manufacturing Engineering Laboratory) and MSEL has demonstrated that small differences in the geometry of the diamond indenters used for the tests represent another important source of the observed variation. These differences arise largely from the lack of satisfactory measurement methods to establish that indenters meet the specified geometry. Such methods have now been developed by MEL, and collaborations are in progress to qualify indenters used in the various national laboratories.

NIST chairs the Panel on Wind and Seismic Effects, established in 1969 as part of the U.S.-Japan Cooperative Science Program. Eighteen U. S. agencies participate in the Panel to develop and exchange technologies aimed at reducing damage from high winds, earthquakes, storm surge, and tidal waves. Since our two nations share particular risks from these perils, this cooperation leverages our efforts to learn what we can from natural disasters to help prevent future damage and suffering. The Panel has eleven technical committees that carry out their work through the exchange of data, technical conferences, site visits, and cooperative research projects.

A similar Panel on Fire Research and Safety was established in 1975 to encourage, develop, and implement the exchange of information in fire and smoke physics, toxicity, chemistry, and risk and hazard evaluation. This activity alone has resulted in over 300 published research papers, the exchange of 40 guest researchers, and seven targeted research projects. Cooperation in the conduct and interpretation of fire tests helped assure the acceptability of wooden structural members in low-rise construction in Japan, thus opening a new export market for U. S. forest products.

In the information sciences, common research problems include the development of tests and performance metrics for emerging technologies. As one important example of activity in this area, NIST has collaborated with Korea to develop better metrics for the Integrated Services Digital Network (ISDN).

Research with environmental application quite naturally requires international cooperation because of its global implications. To advance our understanding of the transport properties of alternative refrigerants, NIST is collaborating under the auspices of IUPAC with researchers from England, Germany, and Portugal to measure, correlate and predict both thermal conductivity and viscosity. NIST has initiated and is chairing the activities of Annex XVIII of the International Energy Agency, the objectives of which are to provide a forum for the exchange of information and data and for the coordination of activities on the thermophysical properties of environmentally acceptable refrigerants and the determination (including experimental measurements and the evaluation and correlation of data) of the thermophysical properties of these fluids leading to the publication of comprehensive, internationally accepted properties bulletins.

In electronics, Japan comes quickly to mind as a nation with much knowledge to share with the United States. As part of the 1993 U. S -Japan Agreement on Cooperation in Research and Development in Science and Technology, NIST is leading a bilateral program to advance the manufacture of optoelectronics components. This U. S.-Japan Joint Optoelectronics Project is funded primarily by Japan's Ministry of International Trade and Industry (MITI). Participants in both the United States and Japan are able to obtain novel optoelectronic prototypes from suppliers in the other country using the services of a broker. The spur for this project is the understanding that an ability to prototype is essential for rapid advancement in any underlying technology, as experience in silicon-based microelectronics has proved. The need for prototyping foundries is even greater in optoelectronics than in microelectronics because the technology is less mature and fabrication facilities are few in number, each with its limited set of capabilities.

Sometimes world affairs provide the necessary introductions for fruitful interactions. NIST is engaged in a number of collaborative projects with researchers in Eastern Europe, sponsored in part by such organizations as the U. S. - Poland Maria Sklodowska-Curie Joint Fund, and the U. S.- Hungarian Science and Technology Program. These many projects, mostly pairing NIST staff with university researchers, cover the gamut of the physical and engineering sciences. Examples include the certified reference materials for bronzes and brasses, the measurements of atomic transition probabilities, and advances in laser frequency stabilization in support of the needs of multi-wavelength interferometry.

Role of Visiting Scientists

To maintain a free flowing atmosphere of ideas and people, NIST today hosts in total about 320 foreign guest researchers, from every corner of the globe, working in every area of endeavor. A visitor from Egypt studies organic thermochemistry; a visitor from China develops theories for the wear maps of ceramics; a scholar from Croatia uses x-ray diffraction to study crystal structure; a student from Uruguay plots strategies for the application of industrial robots; and a researcher from Mauritius studies the critical currents of superconductors used for radiometric measurements. Similarly, over the past 5 years, over 60 NIST researchers have made extended visits to foreign nations to continue their research. Whether visiting Canada to study the effectiveness of oil-spill clean-ups, England to use unique synchrotron facilities, or Japan to view first-hand the management of its telecommunications network, these international assignments have a direct and positive influence on the success of NIST's mission.

International Use of Facilities

The high flux reactor at the Institut Laue Langevin (ILL) in Grenoble, France has hosted NIST staff for measurements of crystal structure factors, which are required for x-ray and gamma-ray spectroscopy. This is the only facility in the world that combines high resolution and neutron flux with a source changing mechanism capable of introducing samples into the high flux region next to the reactor core. The same NIST group collaborates with the Italian Instituto Nazionale per la Fisica Della Materia, using the best data available on crystal structure to determine Avogadro's constant.

Conversely, NIST operates facilities such as the Research Reactor and Cold Neutron Research Facility that attract foreign guest researchers involved in collaborative projects. Approximately 15 percent of the foreign guest researchers at NIST work with neutrons produced at these facilities---on projects ranging from superconductors to lipid bilayers to measurements of the fundamental interactions of neutrons.

Continuing Need for Research in Metrology

Powerful commercial and public pressures are demanding increased accuracy and reliability in electronic, mechanical, physical, and chemical measurements, both for international compatibility and product quality assurance. As industry moves into the 21st century, customers will be won or lost depending upon the quality and cost of their products. The ability to meet national and international standards and specifications will play an increasingly strong role in assuring economic competitiveness. Product quality and international compatibility are driving industrial demand for increased measurement accuracy, not only in corporate metrology laboratories, but right on the factory floor.

At the foundation of ensuring international compatibility and all approaches to disseminating physical standards of measurement lie the primary standards themselves---the standards to which all others are ultimately related. Any country's measurement infrastructure must ultimately be limited by the accuracy and stability of its primary standards. Thus it is important that NIST is a world leader in realizing the ampere and the temperature scale and a key player in efforts to replace the mass artifact by an electronic kilogram. Yet in realizing the unit of time, where NIST a few years ago commissioned the world's most accurate frequency standard, the international standard second is still---as it has been for 10 years---based essentially on the primary cesium clocks of a single European laboratory. Even our claim of having the world's most accurate standard is now no longer true---in 1996 the French succeeded in realizing a cesium atomic fountain frequency standard superior to the NIST optically pumped cesium standard.

In many areas, technological advances have outpaced our ability to measure and control performance. For example, the radiation standards available for calibrating cancer therapy treatment facilities are the same as those used for the past 20 years---fine for calibrating nearly obsolete low-energy x-ray and gamma ray sources, but of no use for the modern, high-energy electron-beam therapy units found in nearly every major hospital.

U.S. technological leadership is threatened. Many nations are increasing their support of metrology and standards activities, especially in certain strategic areas. Success by its nature breeds complaisance. Without increased attention to the vitality of the fundamental measurements, standards, and data programs in the laboratories at NIST, we will not be able to claim the international technical leadership upon which the rest of our international and domestic programs are based.

Plans for Future Activity

NIST managers and scientists have identified key areas of research required for NIST to regain wider international leadership in metrology and to be, at the same time, responsive to the needs of U.S. industry. A list of priority needs includes the following:

- Development of ionizing radiation standards and international intercomparisons to facilitate cooperative agreements and commercial opportunities involving the radiation processing of food and materials and the export of radiation therapy and radiation protection technology.

- Development of optical radiation standards and standard reference materials needed by U.S. industry to demonstrate conformity with international protocols on color and appearance of commercial products such as photographic film, paint, coatings, electronic displays, and lighting products.

- Development of miniature frequency standards based on fundamental, intrinsic properties of materials. This would be done jointly with industry. Miniature cesium-cell standards will be built and systematic effects evaluated to establish accuracy.

- Development of an atomic fountain clock with ten times higher accuracy than the present standard for the units of time and frequency.

- Development of electro-optical techniques and standards for characterizing ultra short laser pulses, ultra narrow-bandwidth light fields, and nonlinear optical materials used to generate and engineer pulsed laser beams for photonic and laser processing applications.

- The development of infrared and visible imaging radiometric standards for thermometric temperature gradient sensing in manufacturing process control and remote sensing applications.

- The development of an ac voltage standard based on the Josephson junction that will provide a fundamental, self-calibrating ac voltage standard useful in industrial electrical calibration laboratories.

- Development of ac resistance standards based on the quantum Hall effect, enabling higher accuracy calibrations to be made in industrial settings.

- Development of quantum-based standards for capacitance and current, based upon the phenomenon of single electron tunneling, offering the potential of simplified and more accurate primary electrical standards.

- Development of measurement techniques and standards for characterizing magnetic nanostructures and giant magnetoresistive effects critical to the development of higher density magnetic storage devices for the computer industry.

- Development of the means to realize more accurately the unit of length through advanced interferometry and optical wavelength standards.

- Development of test data and test methods for assessment of human-machine interface technologies (e.g., spoken and written natural language), mathematical and statistical software, and software diagnostics.

- Development of new, critically evaluated databases for physical, chemical, and materials properties, e.g., machinability of materials needed for advanced manufacturing applications.

- Development of electronic dissemination techniques for delivering reference data to industry for computation-based product design and virtual engineering.

- Development of an electronic kilogram to replace the standard artifact kilogram, the last remaining international standard not related to fundamental physical properties.

- Development of the first international standard for the chemical mole or "amount of substance," needed to establish a system for traceability for chemical measurements on a worldwide basis.

- Development of speciation analysis techniques and standard reference materials for radioactive materials in natural matrices such as Irish Sea and Arctic Sea sediments, as required to make measurements that will make possible important international agreements and policies.

- Development of a secondary, radiation-based internationally accepted temperature scale covering the range from 0 °C to 962 °C is required to support growing industrial reliance on non-contact temperature measurement.

- Development of a new generation of primary flow measurement standards which are both portable and extensible, i.e., can be scaled for use over wide ranges of flow rate and fluid conditions, is required to enable intercomparisons of disparate national flow standards.

- Development of high sensitivity, species specific partial pressure measurement systems based on optical technologies will enable reliable intercomparison of primary standards of vacuum and humidity.

- Development of second generation, controlled clearance piston gauges, based on computationally optimized designs, to provide 10-fold reductions in uncertainties of primary high pressure standards.

- Development of high accuracy, triple point cells of gases such as Ar, N_2, and SF_6 to serve as transportable, reference points pressure measurements.

- Development of a new series of reference methods and materials for measurement of pH at high temperatures and pressures to address industrial process monitoring requirements.

III. Provide Uniform and Accurate Measurements

Sharrill Dittmann*

Abstract

NIST plays a critical role in facilitating U.S. exports by helping to ensure the accuracy and credibility of U.S. measurements and measurement services. Currently, there is no universally recognized system to which all trading partners adhere for ensuring measurement accuracy and credibility. U.S. exporters often must have their products tested in the importing country when that country does not recognize the reliability of U.S. tests, resulting in both higher costs and lost markets. The challenge for NIST as the national metrology laboratory is to provide the critical links between the various U.S. testing and laboratory accreditation systems and the U.S. national measurement standards on the one hand, and foreign governments and bodies requiring U.S. Government assurance of the reliability of U.S. test and measurement results on the other. NIST is well positioned to respond to this challenge. NIST staff already are involved in a broad range of related international activities including as U.S. representatives to several international bodies. However, NIST's capability to provide measurement services has continued to erode. In the interest of U.S. international (and domestic) trade, NIST must strengthen these services.

The Problems to Be Addressed

Uniform and accurate measurements are the foundation of free and equitable trade. They are vital to the achievement of equity in trade, to the fair and honest transfer of goods, and to the minimization of risk in product development and product rejection. Without measurements and standards, the quality, amount, and value of goods traded cannot be known. Without uniform and accurate measurements and standards,[1] fair trade cannot take place.

As the impact of the global marketplace expands, it becomes increasingly important for U.S. manufacturers and producers to demonstrate to the world community that the measurements underlying their products are firmly integrated into the world system of measurements, and that their products meet international or foreign specifications. The U.S. community is under substantial pressure to demonstrate the credibility of its measurements and so, therefore, is NIST. Equally important, the relationship of NIST measurements to those of the rest of the world must be demonstrated and more formally monitored and documented. These changes in the way manufacturers and national metrology laboratories must operate have put new pressures on all laboratories, and increased both the pace at which measurements must be made and the number of those measurements.

Even with the highest quality products, U.S. industry is not assured entry into the world marketplace and maintenance of market share. The flow of products around the world requires overcoming various barriers including proof of comparability of national laboratory standards and services, conformity assessment, mutual recognition of calibration laboratory accreditations and differences in national documentary standards.

The following is an example. The U.S. legal metrology system or "weights and measures" helps to ensure equity in trade for commercial transactions comprising $3.36 trillion---half of the U.S. GDP in 1994. These transactions include sales of foods, petroleum products, grain and feed, agrichemicals, paper products, building and construction materials, and a wide variety of other materials and products which are sold by weight or measure

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[1] The term "standard" in this chapter refers to physical or chemical measurement standards (etalons). Standard in this usage is defined in the *International Vocabulary of Basic and General Terms in Metrology* as "material measure, measuring instrument, reference material or measuring system intended to define, realize, conserve or reproduce a unit or one or more values of a quantity to serve as a reference."

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and have large international markets. Grain and feed sales alone account for $77 billion of the GDP, and even small measurement errors in this and other areas can have an enormous cost impact on either the buyer or the seller. For example, the state of Ohio estimated that a 2 percent error in grain moisture measurements could result in losses up to $44 million to Ohio grain producers. Equity in grain and feed sales also depends on accurate measurement of protein, foreign material, pounds per bushel, and other quality factors that impact the cost of the grain. These measurements are often quite sophisticated and involve support from several measurement services offered by the national laboratory as well as the use of well-established protocols.

When U.S. grain is shipped overseas, the quality and quantity of grain must also be specified, which includes measuring the factors identified above. However, when the grain is received overseas, these measurements are repeated, and the results may be quite different. There is currently no way to establish whether any differences are technically based or whether the confusion in measurement results has been used to mask a trade barrier or malfeasance. Such differences have resulted in grain shipments being rejected or purchased at feed-grain prices even though the original specification was for grain for human consumption. The lack of agreement has cost U.S. suppliers substantial sums of money.

The U.S. Model

In the United States, measurements made for commercial trade purposes are the only ones regulated by government, and only by State and local government. The Federal Government, through NIST, provides mechanisms for harmonization and coordination of statutes and requirements among the states, and ensures measurement traceability through State weights and measures laboratories and field offices. Only in the past 10 years has U.S. legal metrology seen advantages to regulations requiring the preliminary evaluation of prototype commercial measuring devices prior to allowing their sale in domestic markets. All other nations employ some type of preliminary device evaluation prior to permitting their sale in their commercial marketplaces.

For other measurements made for industrial, scientific, and military purposes, there is a myriad of pathways available to tie a commercial laboratory's measurements to those at the national laboratory. The Federal Government's mandated role is to provide the measurement base to support these pathways to NIST. The buyer of the service is free to audit the performance of the seller. Increasingly, buyers of measurement services are requiring preliminary evaluation of a measurement service provider’s ability to provide accurate measurements as demonstrated by third party accreditation programs (including NIST's National Voluntary Laboratory Accreditation Program, NVLAP, which applies ISO standards).

When the Federal Government is the customer of calibration and testing services, the purchasing agency usually audits the seller of these services or equipment to ensure proper quality and technical standards. Each agency has established its own criteria; however, there is an increasing shift towards the federal agencies adopting ISO standards.

The overall philosophy in the United States has been to allow whatever means and methods achieves the measurement goals of the informed end user. This model has been quite successful at dealing with metrology in trade at the domestic level; U.S. manufacturers and measurement service providers deliver high-quality products based on the world's best measurements. Internationally, the story is quite different. There is no single U.S. coordinating body, or agreement at the international level, that coordinates U.S. national metrology at all levels. However, many nations demand that U.S. measurements and measurement services be tied together at the international level.

The current national and international system is not entirely adequate for our needs today. The U.S. governmental bodies do not speak with a single voice, frustrating external trading partners who are attempting to meet trade and other regulatory requirements for sale of their products and services within the United States. There is not a sufficient number of mutual recognition agreements between the United States and its trading partners, frustrating domestic exporters seeking recognition of their products and services overseas.

There is no central clearinghouse of information concerning the status of intercomparisons or resulting data from intercomparisons that complements political statements of equivalency of measurements at the international level. There is no universally accepted set of links and pathways for establishing efficient measurement equivalence among members of the Convention of the Meter and regional trading blocs, and among those intercomparing at the highest measurement level with those intercomparing at the industrial and legal metrology levels.

At the International Level: The National Laboratory and Below

At the level of international and scientific metrology, the Convention of the Meter established the metric system as the worldwide system of measurement and created the International Bureau of Weights and Measures (BIPM) in Sèvres, France, as the body that defines the units of measurement such as the meter and the kilogram. Signatories to the Convention of the Meter, including the United States, frequently compare their national standards with both the BIPM and signatory nations. This links the member nations and ensures that metrology at the highest level can be carried out accurately and uniformly around the world.

Therefore, the additional measurements and measurement coordination that are needed to facilitate trade are possible. These take place not just between national laboratories but also secondary laboratories at the levels of international, scientific, and industrial metrology and involve assessments of the delivery of measurement services (calibrations, reference materials, reference databases, etc.) and of physical and chemical standards that are not maintained by the BIPM. These include standards of force and hardness, reference materials for chemical measurements like gas standards, and databases like properties of refrigerants.

International Legal Metrology

At the level of international legal metrology, the International Organization of Legal Metrology (OIML), established in 1955, works to harmonize the metrology regulations of its member nations. OIML produces recommendations on the design and verification of measuring instruments; other guidance publications; and a certificate system (product conformance documents) which facilitates trade in measuring instrumentation subject to legal requirements. The NIST Office of Weights and Measures has adopted procedures permitting U.S. manufacturers of scales to secure OIML certification based on measurements in the United States. This will allow manufacturers to secure certificates in the United States that will be valid in those countries recognizing OIML recommendations.

Laboratory Accreditation

Some governments require not only that a specified level of quantity or performance be achieved, but also the assurance (1) that our private and governmental laboratories are competent and tied to our national laboratory and (2) that our national laboratory maintain equivalency with theirs and deliver comparable measurement services on U.S. made goods to be sold in those countries. In many countries, measurements in private and governmental laboratories are tied to national standards through a well-documented hierarchy involving assessments by one or more government or quasi-government bodies. The United States has a less bureaucratic and arguably more efficient system. U.S. exporters must conform to the trading partner's model. NIST operates its National Voluntary Laboratory Accreditation Program (NVLAP) and is seeking ways to tie all major accreditation bodies in the United States into a confederation recognized by other nations and international bodies to meet the export needs of U.S. companies.

Regional Cooperation

The international community has begun to address the need for efficient and uniform measurement by forming regional cooperations analogous to and based on trade blocs. Within these regions, organizations have been set up encompassing national metrology laboratories, accreditation bodies, and testing bodies. This chapter deals only with metrology cooperations. For further information on accreditation and testing regions, see Chapter VI.

There are now several metrology cooperations in the world. The United States is a member of two, the North American Metrology Cooperation (NORAMET) with Canada and Mexico, and the Inter-American Metrology System (SIM) with all of North, Central, and South America except Cuba. There are also regional cooperations in Europe (EUROMET), eastern Europe (COOMET) and the Asia-Pacific area (APMP). Others are under development in the Middle East and Africa.

Although these regional organizations have different structures and different goals reflecting the needs of their members, they form the backbone of a worldwide metrology system. In the future, this system should complement the role of BIPM through efficient international measurement comparisons. NIST has chaired NORAMET, provided for its secretariat, and has agreed to operate several international interlaboratory comparisons for SIM. NIST does not have the personnel resources to manage these interlaboratory comparisons, train the participants, and provide technical consultations as the comparisons continue, with the dispatch that would maximize exports.

U.S. Trade in Foreign Markets

Today, U.S. companies are faced with an overwhelming variety of regulations and demands leading to extraordinary needs for guidance, training, and measurement services to be sure that their products are of the specified quality and will be accepted overseas. Bringing credibility to U.S. quality practices, measurements, and standards requires active participation in the national metrology system by manufacturers using calibrations, reference materials, and data, and participating in intercomparisons and proficiency testing. Furthermore, it requires that our national metrology system be sufficiently flexible to meet any requirements imposed by other countries and regions.

An example is a European standard for electromagnetic compatibility, which has caused particular distress among U.S. manufacturers of electronic equipment. Not only must our manufacturers put their products through extensive tests in Europe before they may be sold overseas, but there are also real difficulties in making meaningful measurements. These difficulties are due in part to technical matters, and in part due to the interpretation of the standard. Differences in measurement results may cause U.S. products to be withheld from the European market or to be retested there (with time delays of several months and substantial additional costs). Several U.S. manufacturers have decided to withdraw products from their lines either in Europe or worldwide.

Manufacturers need rapid access to information about international and regional test methods and practices and about intercomparisons that have been carried out between national metrology laboratories and metrology regions. NIST maintains an excellent library of normative standards, which helps industry with the first task, but NIST has no clearinghouse for information on intercomparisons. In addition, negotiations among standards developers must be increased to reduce variations in test protocols that lead to variations in measurement results. The lack of adequate information about or operation of intercomparisons contributes to the use of metrology as a trade barrier.

Why NIST Should Address These Problems

The national metrology laboratory has both a national and an international responsibility. Not only must that laboratory service its own industries and government, but it also must act as a liaison with the metrology systems of other nations. The duties of a national metrology laboratory in today's world include performance of comparisons to support measurements at all levels of accuracy and need, active membership in metrology region(s), examination and characterization of measurements services of other nations, and provision of guidance and training to its customers and international trading partners. At the same time, the laboratory must carry out its traditional role of research to support its measurement services to industry (see Figures 3.1 and 3.2 for examples of NIST services to particular industries).

NIST has been mandated to maintain the U.S. national standards of measurement (with the exception of time, which it disseminates but does not define) and to critically review reference data for industry's use and, as such, is the body with which other nations will seek government-to-government agreements. NIST is uniquely qualified to serve industries' needs for quality assurance and to maintain the international agreements necessary for free trade as a result of its long history of beneficial interactions with U.S. industry as well as strong ties with its counterparts at national laboratories around the world.

NIST is active in the international measurement and standards communities. Examples of this include NIST representation of the United States in NORAMET and SIM, where it works closely with major trading partners throughout the Western Hemisphere; and NIST's chairmanship of the ISO Reference Materials Committee (REMCO), which establishes international guidelines for the production and use of reference materials, for 12 of the last 18 years allowing us to play a major role in this critical area. NIST is the U.S. representative to OIML, giving the legal metrology community a strong voice in international policy deliberations. The Director of NIST's Physics Laboratory is the U.S. representative to the International Committee on Weights and Measures, which directs the BIPM, and NIST staff represent the United States on the BIPM Consultative Committees which advise the BIPM on technical issues.

Measurement Services for the Aerospace Industry:

Calibrations:
dimensional
electrical
mechanical
optical radiation
thermodynamic
time & frequency

Reference Materials:
aerospace alloys
fuels
lubricants
non-destructive evaluation
surface finish
thermodynamic properties

Reference Data:
ivanthermo-pc (Moscow)
materials properties
thermodynamic & thermochemical properties
phase diagrams for ceramists
structural ceramics
corrosion performance
industrial fluids & chemical engineering

Figure 3.1 NIST Services for the U.S. Aerospace Industry

Measurement Services for the Petroleum Industry:

American Petroleum Institute master gauges

Analysis of gasoline & oil
alcohol
chlorine
moisture
nickel
nitrogen
octane
sulfur
synthetic oils
trace elements
vanadium

Flared meters

Flow

Oil gauging tapes

Pressure

Temperature

Thermodynamic properties of hydrocarbons

Figure 3.2 NIST Services for the U.S. Petroleum Industry

In addition, NIST serves the national measurement system with calibrations, reference materials, reference data of unparalleled quality, and with research into new and improved measurement sensors, methods, and models. NIST staff work closely with interested industries, and NIST has developed stringent criteria for the establishment of calibration services and evaluation of data and reference materials. In support of its role in maintaining the integrity of national measurement standards, NIST has the mission of promoting the development and implementation of uniform weights and measures standards and practices to ensure equity in commercial weighing and measuring transactions.

The Approach

The international system is continuing to evolve with the establishment of formal and informal regional trading blocs. With the lack of firm guidance in the form of an international agreement, each nation and region is free to establish its own criteria for the acceptance of measurements and standards from outside its own boundaries. Addressing this problem will require active cooperation within and between the established metrology regions, agreement on the interpretation of existing international intercomparison protocols, guidance to and feedback from U.S. industry on existing criteria for determining measurement equivalence, and technical assistance in meeting those criteria.

A system is being developed to minimize the number of international intercomparisons needed to link national metrology laboratories together. Properly chosen and executed, this system will facilitate the uninhibited flow of goods across national boundaries by allowing measurements required in the country of destination to be made in the country of origin. Through NORAMET, NIST is working to develop and adopt a system to accomplish this. As the members of each region tie their measurement systems together, one (or more) designated regional laboratory(ies) will participate in intercomparisons with laboratories in other regions. In this way, each national laboratory can intercompare with the national laboratories of all its trading partners with greater efficiency at lower costs in resources and time. NORAMET, and NIST's role therein, is an example of how such systems should work elsewhere.

In addition, members of NORAMET ultimately will undertake whatever examination and verification of each other's measurement services is required so that manufacturers do not need to ship products to the buyer's country for calibration or verification. This will end the inefficiency of having to maintain corporate standards traceable to the home country AND pay for calibrations in the country of destination.

For example, NIST's Office of Weights and Measures is working to reduce non-tariff trade barriers that weighing and measuring device manufacturers encounter when exporting their equipment to Canada and other countries. Through agreements between the U.S. National Conference on Weights and Measures and Canada's Measurement Canada, (formally known as Legal Metrology Branch), NIST's Office of Weights and Measures has worked to establish mutual recognition of instrument prototype evaluations of weighing and measuring equipment. This program enables the manufacturer to obtain equipment approvals for both the United States and Canada through a single evaluation, thereby reducing the overall approval costs. Industry has expressed interest in establishing similar agreements with other trading blocs especially with the European Union.

NIST is working with U.S. industry to provide not only measurements, reference standards, and reference data, but to provide the interpretation, guidance and training in meeting foreign standards necessary to compete in the world marketplace. Many of the regulations that other regions and nations have put in place are product-based, not performance-based, and the measurements that must be performed to verify compliance are often ambiguous.

NIST must have the measurement capabilities in place to assist industry in its development of the quality assurance systems necessary for trade in today's world. The United States stands poised in some areas to assume market leadership (e.g., telecommunications synchronization). NIST must assist in the development of new and/or better measurements, in parallel with its work on normative standards and protocols, to ensure that our products have a fair chance to take their rightful place in the world market.

Options for Future Activities

NIST will continue to be an active participant in NORAMET, SIM, OIML, the International Committee of Weights and Measures (CIPM) and the Consultative Committees for BIPM, and other international or regional bodies as appropriate. Work has begun in NORAMET to document the level of comparability of measurement services among the three members. A report on establishing uniform and accurate measurements worldwide was issued by NORAMET. In SIM, our efforts will be concentrated on continuing international intercomparisons of national standards. A 34-country intercomparison of mass standards is underway. Future intercomparisons will be designed not only to establish measurement links among the members, but also to facilitate trade in goods and services. An example would be intercomparisons in electrical and pressure sensors to meet the regulations of the U.S. Federal Aviation Administration (FAA) requiring that aircraft repair facilities for all planes landing in the United States be traceable to NIST. Failure to determine whether traceability to other national laboratories by foreign aircraft repair facilities is equivalent to traceability to NIST would seriously damage our relations with many of our trading partners and their economies, possibly jeopardizing their willing purchase of U.S. goods and services.

NIST will ensure the development and maintenance of a database of international intercomparison results. These data are urgently needed by companies that buy or manufacture products overseas to ensure that the standards on which they are based are firmly tied to the other nation's standards. This database will be accessible on-line to industry and all trading partners including members of NORAMET and SIM.

Another way to increase U.S. exports is to assist our trading partners as they strengthen their national metrology systems. NIST in partnership with private instrument manufacturers and professional scientific and engineering organizations can provide training in technical matters as well as in United States metrology practices and codes, opening up markets for equipment manufacturers while establishing strong technical ties with the staff members of these laboratories. NIST should provide technical training and consultations to the scientific and technical organizations of our trading partners, especially members of SIM and the so-called Big Emerging Markets. Until these nations can make uniform and accurate measurements at an appropriate level, trade will continue to be hampered.

In order to support U.S. industry's need for measurement services, training and intercomparisons (both domestic and international), NIST must maintain state-of-the-art measurement capabilities.

NIST aligns its capabilities with industry's needs by strategic planning, priority setting, and partnering with its industrial and scientific peers to acquire new staff, equipment, training facilities, and upgraded facilities wherever necessary. New Standard Reference Materials and Data will be developed to help U.S. manufacturers meet new challenges. NIST will concentrate its work with existing international bodies to ensure that these new measurement services are understood by our trading partners and fully accepted by them as suitable standards. NIST will continue to pursue the creation of mutual recognition agreements where necessary.

To further assist industry, NIST will also increase its participation in proficiency testing to support the National Voluntary Laboratory Accreditation Program (see Chapter VI). NIST will develop both intrinsic standards and first-principles sensors to enable industry to make measurements with the highest possible accuracy. NIST will also increase the amount of measurement training and consultation that it provides to U.S. industry both to improve the quality of U.S. products and to explain measurement protocols and techniques required by foreign regulations and guidelines.

Through a cooperative agreement between the U.S. Department of Agriculture and NIST's Office of Weights and Measures, NIST is striving to improve measurement accuracies in the importing and exporting of grain as well as in domestic grain transactions. Through this same Office, NIST will support states and local jurisdictions with protocols, model legislation, traceability to NIST, training, and technical expertise for a variety of measurement capabilities to ensure accurate measurements and equity in trade.

NIST will provide training for industry and legal metrology jurisdictions covering requirements and standards for legal metrology. The most efficient way to reach the largest number of participants is to train the trainers, and NIST has been doing this successfully in selected arenas for decades. This program will grow from five classes per year in 1996 to 50 classes per year in 2003. The impact of commercial legal metrology is enormous and the number of areas to be covered is large---approximately 17 different subject areas have been requested for training. Only by training trainers can NIST serve all of industry's needs in this area.

IV. Improve U.S. Access to Developing Markets Through Standards Assistance and Training

Peter L.M. Heydemann*

Abstract

Trade in any market requires an infrastructure that includes not only transportation, mail and telephone systems, electric power, and banking, but also a system of clear and reasonable normative standards,[1] conformity assessments, weights and measures, and import regulations. It also requires competent authorities to set and administer the rules. When these conditions are not fulfilled, when there are arbitrary rules, corruption, or cheating in the market place, then U.S. access to the market is impaired. Many developing markets, and even a few developed ones, do not meet all of the conditions identified above. This chapter discusses the conditions in several developing markets and describes the program that NIST Technology Services is embarking on to improve access to those markets. We concentrate here on influencing authorities to set reasonable normative standards compatible with U.S. or international patterns; to recognize the results of testing done in the United States; and to provide fair weights and measures services. The major tools for achieving these objectives are to establish relations with other governments based on mutual trust and confidence; to provide training, advice, and consultation; and to assist in the establishment of appropriate organizations. This will then be the basis to achieve the objectives described elsewhere in this report for the harmonization of normative standards, for the evolution of a worldwide system of uniform and accurate measurements, and for reaching the elusive goal of "one product, one standard, one conformity assessment." This work is urgent. Other nations are many years ahead of us in establishing systems in developing markets that favor their traders and exclude ours.

Background

Exports are vital for the United States. About 11 percent of the U.S. Gross Domestic Product (GDP) is exported. Exports finance many high-paying U.S. jobs. Much of the growth of GDP in past years was due to increased exports. Over the past 10 years, U.S. exports have increased about 10 percent annually---substantially more than the U.S. GDP increase, but not as much as international trade worldwide.

A Manufacturer Trading in the Global Market needs:
- Competitive products
- Uniform and accurate measurements
- Compatible standards, codes, and regulations
- Agreements on conformity assessment

Figure 4.1 Market Requirements

A manufacturer trading in the global market must have competitive products; that is, products that can compete on the basis of customer preferences, innovation, quality, and price. Traders must also have access to uniform and accurate measurements, usually traceable to a National Measurement Laboratory; compatible normative standards, codes, and regulations; agreements on mutual recognition of accredited laboratories for conformity assurance; registered manufacturing quality management systems; and, soon, environmental quality management systems, all in order to satisfy the importing country's policies and rules (Figure 4.1). The importing country must have competent organizations and staff to set and administer these trade policies and rules in a predictable and transparent manner (Figure 4.2).

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[1]A normative standard is one in which a particular value (size, performance, quality, design) is selected from a range of alternative values.

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In the domestic markets of many countries, the national weights and measures organizations assure manufacturers, traders, and their customers of measurement uniformity and accuracy. For international markets, however, weights and measures systems have not kept pace with the needs of traders. Further, for all legal metrology, for trade in regulated applications, and for complying with contract requirements, these measurements must be "traceable" to specific national standards.[2] Chapter III of this report discusses the actions necessary to provide these traceable, uniform, and accurate measurements for the world market. In 1994, foreign requirements for testing, inspection, and certification affected more than $150 billion of global U.S. exports.

The European Union (EU) is included in the discussions in this chapter because European efforts in key emerging markets, particularly Latin America and the former Soviet Union, impact our efforts to open these markets to U.S. exports.

Problems that Must Be Addressed:

The world market is becoming increasingly competitive. This has led to technical barriers to trade, both intentionally and unintentionally, limiting access to markets, including in large emerging markets such as Latin America. Many of the problems are related to normative standards, conformity assessment testing, and metrology. These technical barriers to trade can be overcome, but there is an enormous amount of work to be done.

A Country Trading in the Global Market Needs:
- A national or regional metrology laboratory
- Measurement standards traceable to other major standards laboratories
- Calibration services for physical and chemical measurements
- A weights and measures organization
- Voluntary standards development organizations
- Regulatory agencies
- Normative standards compatible with international standards
- Mechanisms to meet conformity assurance regulations of trading partners
- Trade agency empowered to negotiate trade agreements
- Information on other countries' standards, assessment rules, etc.

Figure 4.2 Organizations and Functions Needed to Trade in International Markets

Normative standards, codes, and regulations are developed by national or international voluntary standards development organizations and by governments. Where the underlying philosophy or the purpose of the normative standards in the buyer's and seller's country differ, difficulties arise in specifying products and in assuring conformity. For example, in the United States, conformity assurance issued by the supplier is usually sufficient for some sectors. In foreign, regulated markets, third party conformity certification by an accredited laboratory in the buyer's country is the rule, unless a mutual recognition agreement exists. Registration of the seller's manufacturing quality management system under the guidelines of ISO 9000 is usually required. In the future, registration of manufacturers' environmental quality management systems under Guidelines of ISO 14000 will likely be imposed.

In the United States we prefer performance-based normative standards developed by private industry in contrast to design-based normative standards frequently used in the EU and the Commonwealth of Independent States (CIS, the former Soviet Union). Design-based standards tend to inhibit innovation. Some EU normative standards are so difficult, time-consuming, or expensive to conform to, that U.S. companies have

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[2] "Standard" means physical or chemical measurement standards (etalon), in contrast to normative standards.

begun to withdraw products from the EU market. There are as yet no mutual recognition agreements for testing between the United States and the EU. The United States has offered European phone companies free access to the U.S. telecommunications market, but had to withdraw the offer because of the European refusal to give our industry similar access.

> Germany spends more in Guatemala to influence the flow of trade, than NIST can spend in the entire world.
>
> The United States is 26th in the world in export trade support.

Figure 4.3 U.S. vs. German Trade Support

European, especially German, organizations are spending substantial resources on introducing developing countries to the European system of normative standards and conformity assessment. Germany currently spends about $40 million annually on 3 and 5 year metrology projects in South and Central America (see Figure 4.3); Germany is spending several million dollars in India on the new Quality Council of India and its laboratory accreditation; Germany is setting up a Science and Technology Center in Muscat, Oman; Germany has assisted in the design and construction of laboratory buildings of the Saudi Arabian Standards Organization (SASO) in Riyadh, Saudi Arabia; Germany is also planning to donate $2 million for metrology activities in Saudi Arabia. Germany uses this program, as it does in many other countries, to gain a foothold in foreign markets. It introduces German equipment, DIN normative standards, European Union (EU) Directives, and design-based normative standards to tie the host countries to the German or European markets. Other European governments, particularly France and the United Kingdom and their standards bodies, provide similar training, technical assistance, and copies of their national standards to emerging economies in Latin America, Central Europe, and Asia. The European Commission has allocated $2 billion over 4 years for training in developing countries. This is not in the interest of the United States, particularly when it happens in areas of particular interest to us, as in Latin America. NIST needs to counteract this initiative with its own stronger, better focussed, and executed program. The United States has no standards program to match the European effort at this time. If the Europeans succeed in taking control, the United States will not have equal access to emerging high growth markets.

An area that requires a great deal of U.S. attention for economic as well as political reasons are the countries of the Commonwealth of Independent States (CIS). They use normative standards developed by the former Soviet Union's standards organization, GOSSTANDART. These normative standards are incompatible with U.S. or international standards, and certification of U.S. built equipment to these standards is virtually impossible. U.S. companies exporting to the CIS, as well as those with investments there, try to comply with local normative standards and codes. However, the lack of consistent and well-publicized certification and licensing procedures makes compliance time-consuming, expensive, and frustrating. Company complaints focus on three primary issues: (1) lack of written standard procedures and requirements for certification, and their discriminatory application, (2) lack of acceptance of internationally recognized normative standards, and (3) lack of funding for the CIS agencies involved in the certification and licensing process, leading to arbitrary and excess charges. Examples of problem product areas include oil and gas equipment, telecommunications equipment, aerospace, and automotive equipment. These countries also use design-based normative standards. Nor are there any mutual recognition agreements for accredited laboratories with the United States.

Standards organizations in Russia, Ukraine, and Belarus participate in international normative standards development in the International Standards Organization (ISO), the International Electrotechnical Commission (IEC), and the International Telecommunications Union (ITU). Standards organizations in other NIS (Newly Independent States) countries have little or no direct experience in international standards matters. Their regulatory agencies are unfamiliar with the practical application of international normative standards such as those developed in ISO and IEC, and they do not have the necessary infrastructure in place to carry out product certification efficiently. The situation is exacerbated by the fact that NIS standards organizations are distrustful of private business. Russia, Ukraine, and Belarus are the focus of intense competition in economic and trade development between the European Union and the United States. These countries also pose a serious political vacuum.

The Central Asian Republics (CAR) around the Caspian Sea are sitting on the world's largest remaining oil reserves. Improving U.S. access to these markets requires a complete change from their design-oriented, government-imposed normative standards to performance-oriented, normative standards developed by manufacturers and users. Kazakstan and the other Central Asian NIS rely on Russia's GOSSTANDART organization for development and dissemination of normative standards, and use GOSSTANDART's normative standards to manage industrial development.

These normative, design-based standards are enforced by a cadre of CAR inspectors familiar with GOSSTANDART normative standards but who are unable to comprehend or even read the normative standards used by the U.S. oil industry (Chevron, Mobil) in Kazakstan---the standards of the American Society for Mechanical Engineering (ASME); the Society of Automotive Engineers (SAE); the American Petroleum Institute (API); and ISO. An example is the ASME Pressure Vessel Code, which is used around the world but not in the CIS/CAR. Chevron is the largest stakeholder among eight non-CIS companies in the pipeline project from Kulsary to Novorossiysk. Chevron encounters serious difficulties with the import and operation of U.S. equipment because of the unfamiliarity of Kazak inspectors with international or U.S. normative standards. U.S. industry is urging NIST to assist these countries and GOSSTANDART to help access these important markets. Chevron has invested at least $700 million in the Tengiz Oil Field but has had to reduce its spending because of the limited current pipeline capacity.

Saudi Arabia recently introduced an International Conformity Certification Program (ICCP) that may soon be extended to the other Gulf Cooperation Council states---a $14 billion market. This program is designed to prevent importation of low quality merchandize from Asia. However, the rules apply to every country of origin, including the United States, and involve extensive testing of merchandise and pre-inspection of all shipments in and from the country of origin. At best, this creates a delay of several weeks and added cost. Nor does it conform to the rules of the World Trade Organization and the Agreement on Technical Barriers to Trade. U.S. exports to oil-rich Middle East nations with decreasing real income are declining, and more efforts are needed to increase U.S. market share against strong European competition. The Middle East Peace Process requires U.S. assistance in economic development. NIST's Standards for Trade program could contribute significantly to this goal. This NIST program could also be applied to the rest of the Islamic nations in the Middle East and North Africa. NIST has relevant activities and contacts in several of these countries.

Few countries constituting the emerging Market of the Americas (planned Free Trade Area of the Americas, FTAA) have established the organizations and mechanisms (Figure 4.2) needed to deal efficiently with international trade. This poses a problem for realization of the FTAA, and for U.S. exporters. At the 1994 Summit of the Americas in Miami, all Heads of State of the Americas (except Cuba) affirmed their commitment to a Plan of Action leading to the formation of a Market of the Americas. However, most of these countries cannot collaborate effectively because they lack a technological infrastructure, measurement standards, weights and measures, normative standards, and a conformity assessment process. Support from NIST for the establishment of these technical infrastructures would strengthen long term U.S. trade opportunities appreciably.

The Asia-Pacific market covers a few very sophisticated countries with strong trade policies and technical barriers to trade. Other Asia-Pacific nations are less developed but growing rapidly. The Asia-Pacific Economic Cooperation (APEC), of which the U.S. is a member, has committed to free trade throughout that region by 2020 and is actively working on development of the supporting infrastructure.

What Can NIST Do To Improve Access to these Markets?

A. Current NIST Activities by Geographic Area

At the request of the Secretary of Commerce, NIST supports the Office of the U.S. Trade Representative in international negotiations on normative standards and conformity assurance issues, such as negotiations on Mutual Recognition Agreements with the EU. Under the WTO and the U.S. Trade Agreements Act of 1979 which implemented the predecessor Agreement on Technical Barriers to Trade (TBT), NIST has a range of obligations, including maintenance of the National Center for Standards and Certification Information and the WTO-TBT Inquiry Point.

Canada

Our largest trading partner is Canada, and U.S. access to that market is generally excellent. There are few problems. We cooperate closely with Canada in the North American Metrology Cooperation (NORAMET) and the North American Calibration Cooperation (NACC). Both countries work closely with Mexico, our third NAFTA partner.

Mexico

Mexico requires a major effort. In Mexico, the government exercises much more influence on the development of normative standards, conformity assessment, and metrology than in Canada or the United States. A system for developing voluntary normative standards has not evolved yet. There is also a palpable fear that the big industrialized neighbor, the United States, is going to impose its policies on the smaller, developing country. At Congress' request, NIST has placed a Standards Attache in the U.S. Embassy in Mexico City. Also, NIST recently organized a very successful workshop on normative standards in trade for Mexican leaders from government and the private sector. The contacts made by our representative and the understanding gained in this workshop will be very valuable for future collaborations.

Market of the Americas

Beyond Mexico lies the Market of the Americas---Central and South America. NIST collaboration with the Interamerican System of Metrology (SIM), which embraces all countries in the Americas, is described in Chapter III. NIST staff and funding resources in this region amount to only one or two percent of the German standards investment. NIST recently placed a Standards Attache at the U.S. Embassy in Buenos Aires to advise the U.S. Ambassador, to collaborate with the Senior Foreign Commercial Counselor and with the U.S. business community, and to work with local standards officials. The objective is to harmonize normative standards and overcome the numerous standards-related hurdles to U.S. exports. Commerce Department-led Business Development Committees and their working groups on standards are operating in Brazil and Argentina with NIST staff support. NIST's National Quality Program has assisted several Latin American and other countries in developing quality award programs.

Newly Independent States (NIS) Including the Asian Central Asian Republics (CAR)

NIST, with funding and excellent support from the SABIT (Special American Business Internship Training) program, has organized a series of Standards in Trade workshops to familiarize NIS/CAR standards experts with the U.S. system of voluntary and regulatory normative standards, conformity assessment, and metrology, and to establish personal contacts. NIST staff, in collaboration with the ISO, have also conducted seminars in the Central Asian Republics. Seven SABIT workshops have been held for people with responsibility for, among others, medical devices, construction, oil and gas production, and automobiles. Another workshop was organized and funded by NIST for highest level representatives of the standards organizations of Russia, Belarus, Ukraine, and Kazakstan. The NIS delegation was led by the President of Russia's GOSSTANDART. These workshops have been very successful in generating a better understanding of each other's systems and a level of mutual trust and confidence that bodes well for future interaction.

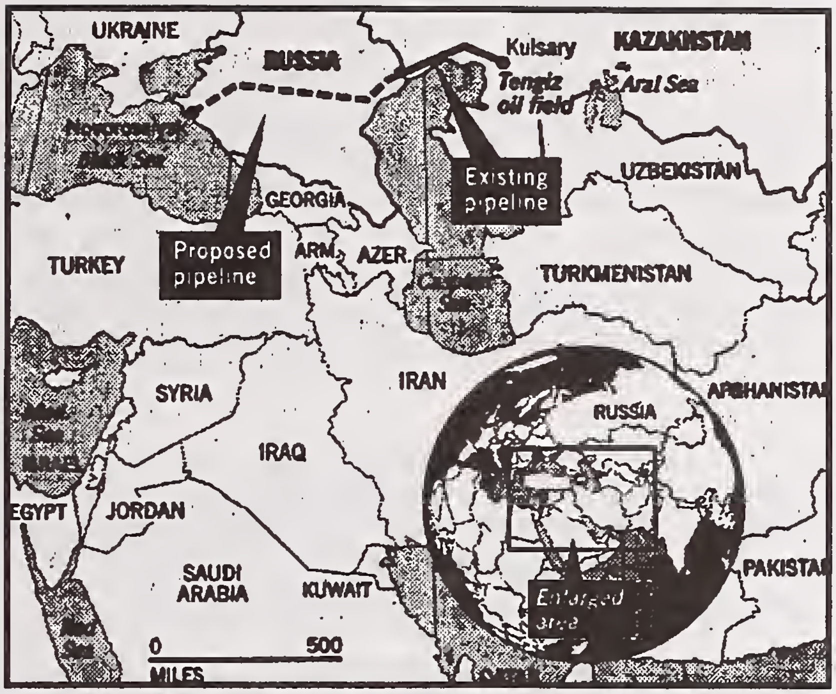

Figure 4.4 The Central Asian Republics around the Caspian Sea

This work is complemented by the Commerce Department's Business Development Committees (BDCs) and specifically their Working Groups on Standards. BDCs have been set up for developing markets such as Russia and Ukraine. The Standards Working Groups are supported by NIST staff.

Senior standards officials in the Central Asian Republics lack access to official Russian translations of international normative standards, and have received no training in the interpretation and use of these standards. As members of the NIS Intergovernmental Council on Standards, Certification, and Metrology, chaired by GOSSTANDART, they are committed to adopt the national normative standards of the Russian Federation as intergovernmental standards, and to cooperate in establishing a common certificate of compliance throughout the NIS. This has not been achieved. In the case of Kazakstan, for example, NIST staff have discussed the situation with the local U.S. business community and with the leaders of KAZAKSTANDART, their national standards organization. However, NIST does not have sufficient staff resources to undertake meaningful negotiations and training.

Middle East

In Riyadh, Saudi Arabia, NIST is represented by a U.S. engineer who works under our contract with the Foreign Commercial Counselor at the U.S. Embassy and, under a long-term standing agreement, with the Director of the Saudi Arabian Standards Organization (SASO). To illustrate the benefits and cost-effectiveness of this program, the American Business Roundtable in Riyadh states that the work of the NIST Standards Representative supported by staff at NIST has increased U.S. exports to Saudi Arabia by between $300 and $500 million per year, with a cost to the U.S. Government less than $500,000. This very successful work of the NIST Standards Expert is described in detail in Chapter V. The agreement with SASO was expanded recently to include all of the Gulf Cooperation Council (GCC) countries. NIST also pursues contacts with other countries in the Middle East including Egypt, Turkey, and Israel, but no major or formal effort exists as yet to collaborate closely on standards and related matters.

Asia-Pacific

NIST enjoys good contacts and works closely with the Asia Pacific Economic Cooperation group, but there is no major collaborative standards program under way. Through its membership in ANSI, NIST participates in the Pacific Area Standards Congress (PASC), a regional body devoted to information exchange and cooperation on standards activities. Collaborations on conformity assessment are described in Chapter VI. NIST has an office of the Standards Representative in New Delhi, India, located at the Indian National Physical Laboratory, and that is staffed with a local hire. NIST maintains excellent contacts in India that were recently expanded by a very successful workshop on Standards in Trade. Markets in South Asia, particularly India, are expected to develop rapidly in the next few years.

European Union (EU)

The U.S. Trade Representative (USTR) has negotiated for 3 years on Mutual Recognition Agreements (MRAs) for mutual recognition between the United States and EU of each other's testing, inspection, certification, or other conformity assessment procedures. Under an MRA, a manufacturer can meet both U.S. and EU standards by undergoing testing, inspection, or certification procedures in whichever country is most appropriate for conformity assurance testing. Two experienced NIST staff members support the USTR in these negotiations and are backed up by additional resources in NIST's Office of Standards Services. Progress on the MRAs is still elusive. At Congress' request, NIST has placed a Standards Attaché in the U.S. Mission to the European Union to assist the Ambassador and the Senior Foreign Commercial Counselor in their efforts to gain and maintain U.S. access to the European market.

In November 1995, industry in Europe and in the United States organized the Transatlantic Business Dialog in Seville, Spain. This was a business-driven meeting aimed at developing an agenda to reduce remaining impediments to transatlantic trade and investment. At this meeting, committees were formed to deal with specific problems. One of these committees deals with standards, certification, and regulatory policy. Participants view this particular committee as the one most likely to succeed.

Current NIST Budget

The NIST FY1996 budget for strengthening access to market activities is shown in Figure 4.5. The amounts shown are expended in-country. In addition there are expenses for the support staff in headquarters.

Current (FY96) Technology Services (TS) Budget for Strengthening U.S. Access to Developing Markets

	$k
Market of the Americas (FTAA)	647
Commonwealth of Independent States (CIS)	400
Central Asian Republics (CAR)	25
Middle East and North Africa (MENA)	390
Asia Pacific Economic Cooperation (APEC)	30
South Asia (SA)	50
Africa (AFR)	0
Total	1,542

Figure 4.5 FY1996 Budget for Improving Access to Developing Markets.

B. NIST Action Plans for Substantially Improving U.S. Access to Key Developing Markets

As stated earlier, a country must have competent organizations and staff to establish and administer reasonable standards-related policies in a predictable and transparent manner (Figure 4.2). Otherwise, manufacturing and trading is risky and expensive. There are many foreign markets where these functions are not available or are carried out in a haphazard fashion, and often riddled with incompetence or even corruption. To improve the situation for U.S. trade interests requires extensive training in a broad range of disciplines, and assistance in setting up and operating competent standards policy and trade organizations. Before that training and assistance can be undertaken, however, the exporting country's authorities, in this case NIST, must develop close professional relationships with the importing country's actual or potential policy makers, metrologists, standards developers, and other government and private sector leaders.

There are seven major regional markets, where improved access for U.S. companies is particularly important. In setting priorities for markets where improved access for U.S. traders is required, Technology Services (NIST-TS) follows the advice of the U.S. government's trade agencies---the International Trade Administration (DOC) and the U.S. Trade Representative (USTR). NIST-TS also considers the Commerce Department's list of Big Emerging Markets (BEM), and responds to pressure from U.S. industry. Figure 4.6 shows NIST's targeted markets in priority order. In addition, Technology Services works with the European Union and with a variety of countries not listed in Figure 4.6.

Some of these, for example the Asia Pacific Economic Cooperation group, include countries that are already fully integrated into the global market, such as Australia, while others require a great deal of work, often at a policy level, such as Korea and China. Some require a great deal of effort immediately. Others, such as Subsaharan Africa, will not merit much attention for many years.

We have developed programs for each of these markets based on information from Commerce's International Trade Administration and its contacts with U.S. companies trading in these markets, and from NIST's own experiences. All of the NIST training and assistance will be very labor intensive, will be tailored to the particular circumstances of each country, and will rely on working with such organizations as the National Conference of Standards Laboratories (NCSL), the American National Standards Institute (ANSI), several U.S. colleges, retired NIST staff, and with many other resources. All efforts will be coordinated closely with the respective countries themselves and with any regional blocs to which they belong. NIST's work in this area is an integral element of "The National Export Strategy" reported to the Congress in October 1996 by then Commerce Secretary Michael Kantor, Chairman of the U.S. Trade Promotion Coordinating Committee.

Free Trade Agreement of the Americas (FTAA planned)
Commonwealth of Independent States/CIS (Russia, Ukraine, Belarus)
Central Asian Republics/CAR (Kazakstan, Uzbekistan)
Middle East and North Africa (MENA)
Asia Pacific Economic Cooperation (APEC)
South Asia (SA)
Africa (AFR)

Figure 4.6 Markets in Priority Order for NIST Standards Assistance & Training Activities

Each area and country has its specific needs. In the case of the CIS, for example, for training purposes and use by local inspectors we need to translate relevant U.S. and international standards into Russian. The result of this concerted effort will be a cadre of well trained, competent, and experienced CIS staff to carry out the functions listed in Figure 4.2. But perhaps the main value is in having direct professional and personal contacts with the people that run the standards and conformity assessment system in the those markets. NIST and U.S. industry will use these contacts extensively. This is the same strategy under which Germany invests $40 million in Latin America alone, with more standards-related investments in other markets including the CAR. As soon as competent organizations and staff are available, we will begin the harmonization of standards, the establishment of conformity assessment structures, and the organization of national or regional measurement laboratories overseeing weights and measures systems. We will attempt to collect used equipment from various sources for the new metrology laboratories and to use in training courses. In Figure 4.7 we list a common set of actions that need to be taken in all of the listed markets in order to achieve and maintain U.S. market access. Once access is achieved, harmonization of standards or development of conformity agreements can begin. NIST proposes to take the following general actions:

(1) More Effective Participation in International Voluntary Standards Development. It is absolutely imperative that U.S. industry participate more vigorously in the work of ISO, IEC, ITU, OIML, and that the U.S. government encourage and support these efforts very strongly. These four international organizations develop most of the international normative standards. The United States needs to influence the formulation of these standards and to expand their use worldwide in order to increase U.S. access to the priority markets identified in Figure 4.6 and to maintain access in all other markets. The American National Standards Institute (ANSI) is the U.S.

representative to ISO and shoulders most of the cost of U.S. membership ($2 million per year), and the burden of administering U.S. participation in the numerous committees and task groups. The total U.S. government contribution is a minuscule $30,000 per year. We believe the cost of membership is part of the government task of providing the scientific and technical infrastructure, and that, accordingly, a "fair share" of the cost should be borne by the government on behalf of all of the country's businesses, government agencies, and the public. That is, there is a need in the United States for a more reasonable federal agency dues structure than exists today. NIST will also work with U.S. industry to assume leadership in more committees and task groups, and get qualified NIST staff to participate consistently in the standards development activities.

The actions to be taken are:

Develop and maintain professional contacts
Provide training in standards-related subjects
Plan collaborative activities
Provide competence development: normative standards
Provide competence development: conformity assurance
Provide competence development: quality systems management
Provide competence development: metrology

Figure 4.7 NIST Actions to Strengthen U.S. Access to Developing Markets

(2) Developing Local Contacts and General Training in Standards-Related Subjects. Workshops and training courses for foreign senior executives and other decision makers will continue to be held at NIST; some courses will be given at selected U.S. colleges. We have discussed such opportunities with several colleges in the United States and with the University of Puerto Rico. In the past, NIST workshops, several of them funded by the U.S. Agency for International Development (AID), have proved to be extremely effective in developing needed contacts with foreign decision makers. Workshops with executives from the Commonwealth of Independent States (CIS) already have led to tangible results. NIST will make further contacts in order to plan programs that address the standards-related problems identified by authorities in these countries.

(3) Competence Development: Normative Standards. In collaboration with the American National Standards Institute and other organizations, NIST will train industry representatives from partner countries in developing normative standards and participating effectively in international organizations (ISO, IEC, ITU, OIML). We will follow U.S. or international practices. Through executive seminars for foreign government officials and private industry representatives, NIST will assist foreign governments to rely much more on voluntary, private sector normative standards. NIST, working with U.S. normative standards organizations, also will provide developing countries with access to relevant databases which promote use of U.S. or international normative standards.

(4) Competence Development: Conformity Assessment. Our aim will be to develop an international conformity assessment architecture based on the concept of "One Product, One Standard, One Conformity Test." To achieve this, NIST needs to develop a high level of mutual trust and confidence with our trading partners. NIST is in an excellent position to do this with its workshops and training courses, its international prestige as a highly respected and neutral organization, and its broad contacts with U.S. industry. In most foreign countries, conformity testing is done by government testing laboratories or by commercial laboratories under strict government rules. But changes are also needed in the United States where a large array of commercial testing laboratories engage in conformity testing. These laboratories are accredited by a large number of accrediting organizations, both government and private. This pluralistic system is not very transparent, and does not invoke great trust by foreign governments. Efforts by NIST, ANSI, and others to create an appropriate U.S. structure for the accreditation of conformity testing laboratories must be completed promptly. In fact, this initiative has already started. Details are discussed below in Chapter VI.

(5) Competence Development: Quality Systems Management. The provisions of the final Uruguay Round have created a more competitive trading environment. Competition in international markets is now focussed more narrowly on products and processes, price, and quality. However, buyers are putting additional demands on sellers for certification of compliance with ISO 9000, and, in an increasing number of cases, certification that products or processes are environmentally friendly (ISO 14000). Buyer demand for third party certification of compliance to ISO 9000 is becoming increasingly widespread. In addition to concerns related to quality systems, there is now an ongoing effort by industrialized countries to promote environmental management systems not only for enterprises within their national boundaries, but also in international trade, through supplier-customer chains. Diverse national measures related to environmental management, as well as the success of the ISO 9000 series on quality management systems, encouraged the International Standards Organization (ISO) to enter the field of environmental management and develop the ISO14000 series of guides for environmental quality management systems. Developing countries have to learn to respond to the requirements imposed on them by the management systems of their customers. Developing countries also have to learn to develop reasonable systems to assure quality merchandize imports (ISO 9000) and protection of their environment (ISO 14000). The emphasis here is on "reasonable", i.e., standards that importers, especially U.S. companies, can comply with. The development of reasonable standards requires a level of competence that we plan to impart to staff dealing with these issues in our priority market countries.

(6) Competence Development: Metrology. Most of the countries in these targeted markets have only rudimentary weights and measures systems. Without a system of uniform and accurate weights and measures, fairness in market access is not assured. Disputes about measurements of amounts or characteristics of merchandise are causing losses to U.S. industry in developing markets. NIST needs to lead a worldwide effort to set up a network for accurate and uniform measurements. We will work with the targeted countries to set up such weights and measures systems that will facilitate U.S. exports. Traditional measurements such as in mass and volume must be complemented by performance measurements such as for digital computer and telecommunications systems, chemical analyses of toxic contaminants in food stuffs, and environmental pollution. The NIST technical laboratories, together with U.S. industry, will train foreign professionals, develop suitable instrumentation for measurement transfer standards, and set up chains of traceable measurements from NIST to foreign standards laboratories. Details on this phase are discussed in Chapter III.

Conclusion

The future of U.S. exports lies in the emerging markets. The Europeans know this and are pursuing a purposeful and aggressive strategy to outmaneuver us by means of standards-related programs and other forms of assistance, in an effort to permanently tie those markets to Europe. The stakes are very high, and we need to act forcefully now to preserve U.S. access to those high growth markets.

V. Support International Standards and Harmonization Efforts

Belinda L. Collins*

Abstract

Standardization issues facing the United States in the global market require development of more effective strategies, both domestic and international. The World Trade Organization (WTO) commitment to harmonized international standards is uniquely difficult for the United States, which relies extensively on numerous private sector standards developers---with active participation by industry, government, consumers, and other interested parties. We have high quality standards which support U.S. technology effectively, but which do not respond adequately to the challenges of the global market. The current U.S. standards system is complex, multifaceted, and comprised of many diverse elements, many of which appear unnecessarily redundant. The lack of central focus and fragmented sector-specific approach is a handicap for the United States in the international standards arena. Much more effective cooperation among government, standards developers, and industry is needed to build effective solutions for supporting international standards, and to work with international partners to develop standards which meet the global challenges. This chapter identifies some of the problems and offers some solutions for NIST to help strengthen the U.S. presence in the international standards arena.

Goals for World Trade: The World Trade Organization

Global markets are changing dramatically, with markedly increasing trade in goods and services among international partners in all regions of the world. In 1995, the United States exported about $700 billion worth of goods and services, and showed its support for world trade by signing both the NAFTA and World Trade Organization (WTO) treaties.

Yet, a large domestic market, good quality, and reasonable price no longer guarantee international market access for U.S. products. Competition is intense and technical barriers to trade often limit or close off access to foreign markets. The Department of Commerce estimates that we could produce additional exports worth $20 to $40 billion right now, if we could overcome all existing technical barriers to trade (TBTs).

Most TBTs result from differences in standards and conformity assessment practices between the United States and its trading partners. While some are legitimately designed to protect human health, safety, or the environment, others exist only to protect a domestic market. The signing of the WTO Treaty makes such protectionist measures obsolete, however. For the WTO to work effectively, the international goal for normative (documentary) standards must be "one standard, accepted internationally, for a given product, process or system." Similar agreement is needed on the procedures used for various forms of conformity assessment, such as product certification and laboratory accreditation or management system registration, to avoid the need to repeat any required testing from country to country. The global marketplace can no longer tolerate needless duplication of effort imposed by the current multiplicity of national standards and duplication of demonstrations of conformity to these standards in different countries. Successful international trade can no longer tolerate a multiplicity of national standards to which a particular product produced in many different countries must conform.

The Uruguay Round of talks, which culminated in the WTO Treaty, gave considerable impetus to the desirability of one standard for a given product---accepted internationally. The Uruguay Round created the WTO as a new institution, and successor to the General Agreement on Tariffs and Trade (GATT). The WTO provides a single, coordinated mechanism to ensure full implementation of an effective, worldwide trading system. The Technical

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Barriers to Trade (TBT) Agreement is a key element of the WTO Treaty. Designed to eliminate use of standards-related measures as deliberate barriers to trade, the TBT Agreement establishes international rules between governments which regulate the procedures by which such measures are prepared, adopted and applied.

The Agreement applies primarily to the central government of a nation, which in turn is responsible for ensuring compliance by local government and non-government bodies. Unlike the earlier General Agreement (GATT) on Technical Barriers to Trade Standards Code, the WTO Treaty requires full participation of all member countries in all aspects of the Agreement. This change effectively triples the membership in the TBT Agreement from about 40 for the GATT to 120 for the WTO Treaty, and gives much more implementation force. The new TBT Agreement, unlike the prior GATT Standards Code, is binding on all members and can be enforced through the full WTO dispute settlement system process. It allows the use of the unified WTO dispute settlement system, and permits withdrawal of concessions under any of the WTO agreements.

> The TBT Agreement addresses the following:
>
> + Technical regulations and standards[1]
> + Conformity Assessment
> + Information and assistance
> + Transparency and information

Figure 5.1

It asks members to use international standards, or relevant parts, as a basis for technical regulations except when such use would be ineffective or inappropriate. It also asks that all members participate in the preparation of international standards, and to give positive consideration to accepting technical regulations of other parties as equivalent. Further, the Agreement states that whenever appropriate, technical regulations should be based on product requirements in terms of performance, rather than on design or prescriptive characteristics. Finally, imports should be treated no less favorably than products of national origin, and technical regulations must not be prepared, adopted or applied with a view to, or with the effect of, creating unnecessary obstacles to trade.

Unlike the earlier GATT Standards Code, the TBT Agreement also covers conformity assessment procedures explicitly. Conformity assessment is defined as: any procedure used, directly or indirectly, to determine that relevant requirements in technical regulations or standards are fulfilled. Conformity assessment procedures explicitly covered include: sampling, testing and inspection, evaluation, verification and assurance of conformity, and registration, accreditation, and approval. As with new standards, proposed new conformity assessment procedures are subject to the Agreement's notification requirements and must not be prepared, adopted or applied so as to create unnecessary obstacles to international trade. The TBT Agreement encourages worldwide use of relevant guides or recommendations by international standardizing bodies. Furthermore, it encourages members to negotiate mutual recognition of the results of each other's conformity assessment procedures to facilitate trade in the products concerned. Finally, the Agreement encourages direct participation by conformity assessment bodies (such as laboratories and accreditors) in foreign conformity assessment procedures.

A key element of the WTO, and its predecessor GATT, is information exchange and transparency. All WTO members are expected to maintain Inquiry Points for providing information to the WTO Secretariat on proposed changes in their regulations that may affect trade. Members are also requested to provide technical assistance regarding establishment of a national standardizing body, regulatory bodies, or bodies for the assessment of conformity with technical regulations. This includes establishment of institutions which would enable members to fulfill the obligations of membership or participation in international or regional systems for conformity assessment. The TBT Agreement also encourages bilateral and multilateral agreements between member countries on issues related to technical regulations, standards, and conformity assessment procedures.

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[1] In the TBT Agreement, technical regulations are defined as product characteristics or related processes and production methods with which compliance is mandatory. Standards, on the other hand, are defined as documents approved by a recognized body that provide for common and repeated use of rules, guidelines or characteristics for products or related processes and production methods with which compliance is not mandatory.

In response to the GATT, and now WTO, requirements, NIST established and maintains the National Center for Standards and Certification Information (NCSCI). This Center serves as the U.S. Inquiry Point for non-agricultural products for both the WTO and NAFTA. It also serves as the U.S. ISONET member, meaning that it provides standards-related information to all ISO members. Proposed regulations for animal health, safety, and pesticides are notified by the U.S. Department of Agriculture to the WTO. NCSCI notifies all other proposed U.S. regulations to the WTO. In 1995, NCSCI notified 29 proposed regulations to the WTO Secretariat, primarily for motor vehicles, medical devices, food additives, upholstered furniture, and meat and poultry products (primarily for labeling and packaging).

International Standards Activities - Background

Although the WTO Agreement stresses the need for members to participate in the development of international standards, it does **not** specify the organizations which develop such standards. There are, however, two primary international voluntary standards organizations, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). The United States is represented at ISO by the American National Standards Institute (ANSI) and at IEC through the U.S. National Committee (USNC) to the IEC, sponsored by ANSI. The United States participates in most of the 184 ISO Technical Committees (TCs) and the 87 IEC TCs, as well as in the Joint Committee, JTC-1, for information technology issues. The United States is a P-member (voting) on 141 TCs and on 612 Subcommittees (SCs) for ISO, and 80 TCs and 100 SCs for IEC, as well as on JTC-1. Furthermore, the United States holds the Secretariat for 33 TCs and 91 SCs for ISO, and 13 TCs and 21 SCs for IEC, and chairs approximately 27 committees and subcommittees for the two organizations.

As presented above, the standards picture appears straightforward, but numerous complications occur because a product, system or process may be covered by voluntary standards in one nation, yet be a regulated entity in another. The mismatch among standards and regulations further complicates agreement on international procedures for accepting foreign products. Thus, in addition to ISO and IEC, there are numerous international treaty organizations in which government-to-government discussions of both standards and technical regulations occur. These include Codex Alimentarius (for food products); the United Nations Economic Commission for Europe (UNECE, in which many standards for European automotive products are produced); the Organization for Economic Cooperation and Development (OECD); the International Telecommunications Union (ITU); the International Organization for Legal Metrology (OIML); and the International Bureau of Weights and Measures (BIPM), among others. The United States is represented in these organizations by the U.S. Department of State, with technical assistance from relevant Federal agencies such as the Food and Drug Administration (FDA), the U.S. Environmental Protection Agency (EPA), the Federal Communications Commission (FCC), and the National Institute of Standards and Technology (NIST). The United States is also represented in regional agreements, such as the North American Free Trade Agreement (NAFTA), the proposed Free Trade Area of the Americas (FTAA) and the Asia-Pacific Economic Cooperation (APEC), by the State Department with active participation by the Office of the U.S. Trade Representative (USTR) and the Department of Commerce International Trade Administration (ITA). The various government-to-government trade agreements are negotiated by the USTR, and then implemented by the appropriate Federal agencies. Another international discussion concerning trade and standards, the Transatlantic Business Dialogue (TABD), is an alliance of industry representatives from both sides of the Atlantic who became concerned with the slow pace of the Mutual Recognition Agreement (MRA) talks between the United States and the European Union. They first met in Seville in 1995 and recently in Chicago to explore common issues and arrive at some mutually agreeable solutions for the trade negotiators to consider. At the heart of these talks is a discussion of common standards and conformity assessment concerns which hamper the flow of goods and services across the Atlantic in both directions.

Domestic Standards Issues and Problems

The United States is faced with a particularly difficult situation in the international arena where most nations are represented by central national standards bodies. Most countries participating in international standards activities have a single, government-recognized, and often government-funded national standards body. The United States does not. Unlike most other nations, the standards development system in the United States is private and voluntary, with almost no direct support from the Federal Government.

As the United States competes in the global trading market, it is faced with numerous problems due to the absence of an agreed-upon national infrastructure for standards and conformity assessment. It is not that there are no structures for these activities; on the contrary, there are many successful (and competing) entities for both standards and conformity assessment activities in the United States. The U.S. systems for standards and conformity assessment are diverse, decentralized, often competitive, and divided among the public and private sectors. Without any central responsibility or authority, these activities have proceeded very successfully along sector-specific lines for almost a century. U.S. decisions about authority and responsibility have not been made deliberately with a view to providing support for international trade, although they do work well to support the goals of health, safety, the environment, and above all else, specification of products, processes and systems. While the European Union (EU) has been most active in building a regional, agreed upon technical infrastructure for its members, the United States has continued to adhere to a pluralistic and uncoordinated series of systems for its many standards- and measurement-related activities. Continued reliance on the existing systems significantly hampers the United States as a major player in the global market. The United States does not play a leadership role in defining the elements of, or procedures for, ensuring that the technical infrastructure works to support industry's needs worldwide. Consequently, we work in a reactive mode, and our good technical procedures and standards are often ignored, because they are not reinforced or promoted by a recognized authority.

It has been extremely difficult to develop strategic policy positions and coordinate efforts among U.S. entities concerned with standards due to the numerous players. There are approximately 400 U.S. standards-developing organizations (SDOs) which develop standards for an enormous variety of products, processes, and services, usually along sector lines. The result is approximately 41000 voluntary standards, developed primarily by about 20 SDOs (of the 400 mentioned above), and used in all industrial sectors---ranging from agriculture, building technology, and fragrances, to vehicles and information technology. Figure 5.2 presents an overview of the mix of SDOs and topic areas.

The ten major U.S. domestic standards developing bodies, based on the number of standards they develop and maintain:

ASTM (formerly the American Society of Testing and Materials)
U.S. Pharmacopeia
Association of Official Analytical Chemists (AOAC)
American Petroleum Institute (API)
Cosmetic, Toiletry and Fragrance Association (CTFA)
Society of Automotive Engineers (SAE)
Aerospace Industries Association (AIA)
Association of American Railroads (AAR)
American Association of State Highway and Transportation Officials (AASHTO)
American Society of Mechanical Engineers (ASME)

Figure 5.2

Other major U.S. standards developers are: the Electronic Industries Association (EIA), the Institute of Electrical and Electronics Engineers (IEEE), and the National Fire Protection Association (NFPA). While the U.S. standards scene is largely organized by sector (as indicated by the list above), there is some overlap. Thus, NFPA, ASTM and UL (Underwriters Laboratories) all write standards related to fire and building safety. SAE, ASTM and API write standards for petroleum products and vehicle emissions. Selecting among these apparent competitors can be difficult for a user, whether in government or in the private sector. ANSI has moved recently to require that any ANSI accredited standards developers file a notice summarizing the intended content of a proposed new standard and asking for comment. If there is duplication with an existing activity, ANSI will work with the SDO to resolve it. The extent to which the presence of competition among U.S. SDOs helps or hinders the use and growth of U.S. technology is unclear.

While the process for developing standards within the United States is reasonably clear, as long as one accepts the premise that it typically (but not always) proceeds along sector lines, it is not clear at the international level. Many U.S. SDOs develop standards which are used internationally. Thus, ASTM, IEEE, NFPA, ASME and SAE, among others, publish standards which are used internationally, and which often have extensive international participation in their development. Unlike ISO and IEC, membership in these organizations is by individuals, not national bodies. Their standards development process is transparent and open to all interested parties. Many standards developed by these U.S.-based organizations, such as the ASME Boiler and Pressure Code which is used in 54 countries, are adopted by national bodies or by foreign governments. The result is that U.S. standards often support the technical regulations of some foreign countries, even though those standards may not have gone through the ISO/IEC standards acceptance process. Consequently, these U.S.-based standards are often truly international in nature, reflecting the best technical input from experts from around the world. However, because they are not supported or recognized by "national" bodies, as in the ISO/IEC process, they are not perceived or identified as being international, and may therefore be disregarded. This is particularly true if a nation or region wishes to field a competing standard which freezes out U.S. or other national technology. There are suggestions that this type of behavior is common within the European standardizing bodies (CEN and CENELEC), which develop regional standards, and then support them in ISO and IEC. Their 18 votes readily outweigh one U.S. vote. Meeting this challenge requires coordinated policy development among U.S. industry, U.S. government agencies, and U.S. voluntary standards bodies.

We believe the international community must consider the central tenets of each U.S. SDO as it works through issues related to international standardization. These include: commitment to the voluntary consensus process including consensus voting, openness, transparency, balanced membership, and due process with a right for appeal. Another central commitment in the United States is to active participation by all affected parties, including industry and government, but without government domination. The standards development process usually works well within a sector and secures the best technical input and resulting standard for its members. For many years, U.S. standards have been the handmaiden for U.S. technology. If a product's characteristics are specified by a U.S. standard, that product is likely to represent the best U.S. technology. Acceptance of the underlying standard supports U.S. technology. Clearly, U.S. technology will benefit to the extent that U.S.-developed standards, based on U.S. technology, are accepted as the "international" standard. Because the United States does not have an automatic process for sending its standards through the international process, and because it has not always participated in the development of ISO/IEC standards, it is particularly and peculiarly handicapped in getting its standards formally accepted at the international level. At the same time, a number of countries use standards developed by U.S.-based SDOs, and are uncertain whether to replace these with standards carrying an "international" label.

Although the language of the WTO Agreement supports the goal of one standard for a given product, recognized (and used) internationally, the many signatories are a long way from meeting this goal. Obviously, the U.S. standards system with its multiplicity of SDOs and standards is particularly vexing to those looking to harmonize or accept one standard for a product for international use.

The United States also incurs significant domestic costs as government agencies and industry face multiple, duplicate standards and conformity assessment procedures. A recent survey indicates that a single laboratory could need between two and ten accreditations to meet the differing demands for documentation, not accuracy, imposed by its customers; one laboratory reported that it was the proud possessor of 101 separate accreditations! These increase product cost, waste time and manpower resources, and may be perceived as a technical barrier to trade.

Still another concern, a major one for U.S. SDOs, is the possibility that their activities may be preempted by an organization such as ISO/IEC, thereby depriving them of their intellectual property and publication income. As foreign governments specify use of international (meaning ISO/IEC) standards, U.S. SDOs and U.S. product technology supported by these standards become increasingly threatened. While this might appear to be purely a revenue issue for the SDOs, it is not that simple, because many U.S. standards are part of the U.S. business structure and have become part of the U.S. regulatory infrastructure through adoption and use by governments at all levels. Since many standards are used in regulation at the national, state, and local level (for example, NFPAs Life Safety Code is referenced in whole or part by most building code authorities throughout the nation), these issues are of vital concern to the health, safety and protection of the environment within the United States, as well as to those concerned with trade promotion and export of U.S. technology. There is, for example, the potential for an ISO/IEC standard to be developed that freezes U.S. interests out of a particular market sector because we could not resolve individual SDO concerns about revenue stream and intellectual property, or because a U.S. company and other interested parties failed to support U.S. participation in the relevant international committee. We must determine the extent to which competition among SDOs keeps the United States from speaking with one voice at the international level, and then develop strategies to ensure that our commitment to free-market competition, sound technical input, and openness and transparency in the standards development process do not sandbag us in the international arena.

The WTO Agreement commitment to work toward harmonized standards is particularly difficult for the United States because of its fragmented standards system. There is no official, formal commitment in the United States to support or achieve harmonization with international standards. In contrast, the Japanese government recently committed Japan to replace its existing standards with harmonized international (ISO/IEC) standards. Canada has made similar commitments for using IEC standards. A key challenge to the United States in making the WTO and NAFTA effective realities is a commitment to harmonization, while working to ensure that U.S. concepts and technology have a real influence on the standards accepted around the world, and on the organizations which develop these standards.

There are some on-going formal harmonization efforts within the United States, most notably with Canada. For a number of years, Underwriters Laboratories has worked to harmonize many U.S. and Canadian standards for electrical safety. Similar efforts have been undertaken, again in the electrical sector, including with Mexico under a trilateral NAFTA standards activity. This activity recently has been hampered because the Canadian government has decided to adopt IEC standards, but the United States has made no such commitment. Other efforts within the United States involve gas appliances and the building community, where the three U.S. model building code organizations (ICBO, BOCA, and SBCCI) are working toward greater harmonization and a possible national building code in the future. Thus, the United States already has a National Electric Code and a Life Safety Code, and is working slowly toward a national plumbing code(s). ICBO is also working closely with authorities in western Canada and Japan to harmonize certain building code requirements.

Despite these limited, sector-specific and private sector based, movements toward harmonization, the United States has yet to make a national commitment to harmonization. However, it is very clear that industry the world over will benefit from achieving the goal of one harmonized standard, accepted worldwide. Yet, and as indicated earlier, the various players in the U.S. standards system have failed to develop a coherent strategy for achieving this goal or presenting a better goal---and thus do not meet industry and consumer needs. This hurts the United States as we implement the WTO, and work with international standards bodies such as ISO and IEC. Often the United States is perceived by other international participants as not interested in, or uncommitted to, international standards efforts.

Participation in ISO/IEC activities is frequently funded by multinationals or by governments. Since the U.S. Government does not fund such participation directly, it is left to industry to get itself to the table. Yet, many emerging high tech U.S. companies are small to medium-sized, and have difficulty in participating in domestic or international activities; their views frequently do not get considered in standards activities, particularly at the international level. The U.S. standards developers and industry must make greater efforts to involve these companies, and their trade associations, in international activities. NIST could further this process through greater attention to international standards development by its Manufacturing Extension Partnership Program (MEPP) centers so that small and medium-sized companies are aware of developments and opportunities to participate.

The lack of U.S. commitment to international standards has led to wide differences in U.S. participation in such activities. In some sectors, particularly information technology through JTC-1 and construction machinery, U.S. participation has been strong and consistent. In other sectors, there has been no activity. Without strategic planning across all sectors, our efforts are suboptimal, and reactive rather than proactive. Despite our lead in many technologies and our strong economy, we fail to set the agenda for the world, or even to show up for some activities.

Continued failure to develop U.S. national policies will harm our industry irrevocably because the technical standards it needs to function in the global market will be set by others. The various public and private entities concerned with standards-related measures must work together to build workable systems for domestic activities within the United States---systems which also function effectively internationally and support U.S. technology and industry in the global market.

The U.S. Objective

The U.S. standards community has begun to recognize the urgency for strategic planning to meet national needs in the global market. For several years, the ANSI leadership has worked with its constituents, including SDOs, industry, and government to improve domestic cooperation for more effective international representation of U.S. interests, and to build alliances with foreign national and regional standards bodies. NIST is working with ANSI to help delineate responsibilities of and develop workable relations among industry, SDOs, and government agencies, and to improve communications among all parties to strengthen the voluntary standards system and to provide a coherent U.S. voice in international discussions.

All of the standards entities in the United States must work together to define and implement strategic standards goals to ensure that U.S. products can compete successfully on a level playing field and that U.S. technology has an opportunity to form the backbone for standards used worldwide. We must decide whether our current disaggregated strategies truly meet our long-term interests effectively. Government and the private sector must work together to develop and implement plans to ensure that the standards process continues to contribute to the nation's economic welfare. We must address the particular and unique U.S. issue of competition among standards developers, both domestically and internationally, and determine the extent to which such continued competition meets industry and government's needs effectively. It is time to consider whether the focus or support should be on the standards industry or the manufacturing and service communities, and modify our strategies accordingly. The time has passed for internal conflicts to keep us from providing strong international leadership in standards. Effective resolution of these issues requires active cooperation among all parties---standards developers, industry, and governments at all levels, as well as a keen awareness of the benefits from such heightened cooperation.

The Unique Position of NIST

NIST is uniquely positioned to assist in developing solutions for the standards issues and problems identified above. Because the international standards arena relies on governmental entities as responsible for standards and conformity assessment policies, some U.S. government backing of a U.S. standards process is needed to assure their acceptance by the international bodies. This does not mean that the government must write the standards, but that it must stand behind those who do. NIST can put forth the U.S. government's policy proposals for harmonization of standards as a neutral third party, and in its traditional role of technical expert. Furthermore, our trading partners demand measurement traceability to national standards; NIST serves that key role too.

On March 7, 1996, the President signed the National Technology Transfer and Advancement Act (PL 104-113) into law. The Act directs NIST to coordinate with other federal government agencies to achieve greater government reliance on voluntary standards and conformity assessment bodies, with lessened dependence on in-house regulations (such as mil-specs). The Act also instructs NIST to coordinate with state and local agencies on standards matters, and gives NIST a central role in coordinating conformity assessment activities with government agencies and the private sector. NIST developed and reported an Implementation Plan to Congress in June 1996 which outlined activities with other government agencies and the private sector to build workable systems for standards and conformity assessment that will meet the needs of U.S. industry in a global market. PL 104-113 grew out of recommendations made by the National Research Council (NRC) in its publication, "Standards, Conformity Assessment and Trade for the 21st Century." The participants in the NRC study, including industry, recommended greater responsibilities for NIST and asked for a NIST-ANSI Memorandum of Understanding (MOU) to define the NIST and ANSI roles in developing, implementing, and supporting a national standards strategy.

NIST believes strongly that the U.S. standards development system must continue to be industry-led, government-supported, and based on a private sector, voluntary process. Resolution of our problems is not greater federal control, but greater cooperation and communication among all affected parties. NIST must work with ANSI and the SDOs to ensure that other nations recognize the key U.S. governmental role in the U.S. standards system and to ensure that U.S. private sector entities recognize the new U.S. international responsibilities entailed by the WTO. Many U.S. manufacturers clearly believe that the current standards system is not adequate to deal with the changing international scene, and believe that all concerned must work together more to develop viable strategies for the future. The United States is committed to the international harmonization of standards and conformity assessment activities; we must implement that goal without relinquishing the strengths of our existing standards systems.

Current NIST Standards-Related Activities

NIST has long been a source of scientific and technical information and assistance to the U.S. private sector and Federal agencies, as well as to state and local agencies. NIST publishes and updates a wide range of informational directories on standards-related activities, including domestic product certification programs, laboratory accreditation, standards developers, and extensive technical information used in the development of specific standards. NIST staff participate as technical experts on many standards committees, both domestic and international. Currently, about 365 NIST staff are active on standards committees, 255 domestic and 110 international. There are a total of 1173 NIST memberships in various standards committees, representing 71 national organizations and 27 international organizations. NIST staff also serve as members of numerous SDO boards, including ASTM, CIE, ASME, IEEE, ASHRAE, IESNA; and the NIST Director is a permanent member of the ANSI Board of Directors.

The breadth and depth of NIST involvement in the development of international standards is extensive. NIST has long been a world resource for technical input to international standards. Each of the seven technical laboratories has provided extensive technical and policy support for a wide range of activities. This long-term support for standards has extended from optics to building technology, from information technology to materials, and from chemical measurements to machine technology and semiconductors. For example, NBS/NIST staff were active in the 1920's in developing the "CIE standard observer" which is an integral response function included in all photometric instrumentation today. NIST staff have actively worked to promote international performance based standards that allow easier introduction of innovative building technology. Similarly, NIST staff have developed international interface standards for flat panel displays, as well as in developing the global standards for interoperability among peripherals (printers, discs, tapes, etc) used in small computers such as laptops and personal computers. Other specific examples include: NIST's technical, policy, and secretarial support for software and standards for the exchange of product model (and architectural design) data (STEP) among manufacturers (now ISO standard 10303); characterization of ceramic powders and input into international standards; and the basic measurement technology and technical input needed in standards for optical fibers used in the telecommunications and other high-tech industries. NIST membership in international organizations and their committees is: ISO (54); IEC (23); JTC-1 (22); CIE (14); RILEM (5); CGPM (5); ITU (4); and VAMAS (3).

NIST cooperation in the U.S. voluntary standards process, including active participation in the ANSI Federation, has long been a priority. In fact, NIST (NBS at the time) and private sector SDOs jointly established ANSI in 1919. The ANSI-NIST MOU of 1995 commits both parties to facilitate communication throughout the U.S. standards community and to work to make the U.S. standards system more effective. The MOU recognizes ANSI's role as the U.S. member body of ISO, IEC (through the U.S. National Committee), PASC and COPANT. NIST and ANSI are also cooperating in the development of the National Standards Systems Network (NSSN) which will shortly provide on-line access to information on standards and conformity assessment information, both domestic and international. This system will speed the flow of information, provide access to standards, and allow development of standards on-line.

To expedite the flow of standards-related information, NIST supports a network of standards experts stationed in major markets (the European Union, Saudi Arabia, India, Mexico, Argentina, and soon Russia). These experts provide technical assistance to Embassy staff on standards-related issues, provide information to U.S. business, facilitate information exchange with foreign regulators and standards developers, and provide information to other U.S. Federal agencies. In addition, NIST offers formal training for standards and metrology experts from around the world on U.S. standards, regulations, and conformity assessment practices. NIST has conducted ten two-week training sessions for representatives from the Commonwealth of Independent States (CIS), Mexico, Argentina, and India, and shorter sessions for China, Japan, and the international telecommunications sector. Staff from NIST, other Federal and state agencies, SDOs, and other private sector representatives participate in these seminars, providing a valuable opportunity for education, information exchange, establishment of important contacts, and development of common goals between U.S. and foreign counterparts.

NIST has translated key documents and handbooks (including some in weights and measures and laboratory accreditation) into Spanish to support NAFTA and hemispheric initiatives. These efforts spur greater use of U.S. technology, standards, and testing practices, and strengthen our competitiveness in the global marketplace while reducing technical barriers to trade. As noted earlier, NIST's WTO and NAFTA Inquiry Points provide essential information on standards and regulatory developments that might affect global trade.

In support of the development and use of secure information technology (IT) products and services, NIST is providing leadership for the harmonization of Common Criteria for IT Security. As the worldwide market increasingly demands secure computer systems (to support electronic commerce among other services), timely international standards on security requirements and evaluation procedures will benefit U.S. providers. U.S. providers will benefit from NIST leadership as the international standards critical to their continued competitiveness are developed. (In 1994, the leading U.S. providers of IT products and services had worldwide revenues of $323 billion, and employed more than one million people in the United States.) NIST is also supporting the IT industry by working for international acceptance of U.S. test results. One way in which NIST accomplishes this is by participation in organizations such as the North American Interoperability Policy Council (IPC), with membership from Canada, the Information Technology Industry Council (ITI) and NIST. The IPC provides the North American focal point for the development, coordination, and harmonization of policy as it pertains to demonstrating interoperability for Information Technology and Telecommunications (IT&T) products worldwide. This activity illustrates the proactive public and private sector cooperation underway in the IT arena in North America.

As demonstrated by the IT activities, NIST must continue to work actively with U.S. industry in all sectors to get more participation in international standards activities. Only through regular participation by informed experts can the United States hope to work effectively in the IT international arena. A recent issue related to water meters, in which an ISO standard did not reflect U.S. technology, arose in part because the United States did not participate in the relevant committee for ten years. Similarly, NIST must work with its colleagues throughout the Americas and Asia to develop international standards which are truly global, not just European. Again, participation by all who are likely to use the resulting standards is key.

Other Federal Activities and NIST Role

The Federal Government currently takes part in the U.S. voluntary standards process as a purchaser, participant in standards development, provider of technical input and advice, trade promoter, and partner with the private sector. The government also issues regulations which can complement, override, supersede or conflict with voluntary standards activities. The October 1993 revision of OMB Circular A-119, and the National Technology Transfer and Advancement Act (PL 104-113) strongly encourage agencies to increase their reliance on voluntary standards, particularly those that are internationally accepted. The Federal Government as a whole has been challenged to work more effectively with the private sector to improve the current standards process to deal with the changing international scene and to implement PL 104-113.

The sector-specific approach used for the U.S. standards developers is replicated at the Federal level making it difficult to approach standards-related issues strategically. Yet, coordination among all Federal agencies is essential as the United States works to develop and implement standards strategies that are effective internationally. NIST has redoubled its efforts to work with other federal agencies in standards policies and activities through the Interagency Council on Standards Policy (ICSP) which it chairs for the Secretary of Commerce. The ICSP, consisting of senior standards officials from Federal agencies, coordinates federal efforts on standards and conformity assessment under the authority of the Office of Management and Budget (OMB) Circular A-119, and now PL 104-113. The ICSP now meets quarterly, and has designated working groups for database directories, ISO 9000, laboratory accreditation, regulatory issues, and standards policy. The work of one of these groups resulted in the formation of the Government and Industry Quality Liaison Panel (GIQLP). This panel consists of key Federal procurement agencies and industrial suppliers who have signed a Memorandum of Understanding which commits them to require only one quality system, such as ISO 9000, for their suppliers. The ICSP reports annually through the Secretary of Commerce to the OMB with respect to agency use of, and participation in, voluntary standards for regulations and procurement.

Thus, NIST works with other U.S. Federal agencies to develop and implement an effective strategy to balance industry and regulatory needs while also pursuing trade objectives. NIST is taking a close and comprehensive look at the demands placed on such agencies, and is coordinating the setting of priorities to minimize duplicative or competing activities while encouraging implementation actions. Reliance on a coherent standards strategy will enable us to present unified U.S. positions to the outside world. New activities in the occupational safety and environmental areas being considered by ISO and IEC provide a critical test of the effectiveness of the cooperative relationship being built between the U.S. Government and the private sector in the standards arena.

In short, close coordination and cooperation between the U.S. private sector and federal agencies will provide systems for standards and conformity assessment that are led by the private sector, but which have the government seal of approval demanded by our trading partners. We must ensure that the United States speaks with a single voice in the international arena. Together, we can make the dream of open markets that meet the health, safety and environmental needs of consumers a reality.

Problem Resolution

General Approach

The breadth and depth of the preceding issues make it clear that a vast array of tasks must be completed by many parties over the next several years to achieve the goal of effective participation in, and harmonization of, international standards. Of necessity, these efforts must occur in sequence, and will require commitment to a continuing and increased annual effort by NIST, Federal agencies, and the standards community.

Working with affected interests, NIST has identified specific tasks needed to achieve a workable technical infrastructure in standards and conformity assessment. Completing these tasks requires NIST's continued strong participation in the ANSI Federation and work with all Standards Developing Organizations (SDO's) toward a national but decentralized system. By law, NIST and the ICSP must develop consistent federal policies for use of voluntary standards and participation in the standards development process. The Technology Transfer and Advancement Act commits NIST to work with state and local governments to coordinate and facilitate their participation in the standards arena. NIST must provide the public sector leadership to make our distributed system of standards and conformity assessment practices support U.S. goals for world trade and outreach to developing markets.

Supporting Analyses

An essential first step in developing a U.S. national strategic standards policy to meet both domestic and international standards needs is a determination of the effectiveness of the current U.S. standards system for the constituents it serves. The preceding sections have identified a number of problems which should be analyzed in much detail. We need to identify which ones really exist and those which are purely perceptual, and then determine the "economics" of the principal ones.

First, NIST should analyze the cost of the diffuseness of the U.S. standards system on industry and technology. We must determine if this hurts U.S. technology internationally, as well as the impact on U.S. multinationals (who may prefer an international standard to a U.S. standard because they sell products to the world market). This analysis should be on a sector-by-sector basis. It should include: definition of major sectors; identification of key regulations and relevant regulatory agencies; identification of key standards and relevant standards-developing bodies; and identification of relevant conformity assessment requirements such as product certification, manufacturers' self-declaration, laboratory accreditation, and management system registration---again on a sector-by-sector basis. This analysis must also assess the benefits of standards and of participation in their development.

In conjunction with ANSI and the SDOs, NIST should ascertain the extent to which the United States uses "international" standards. This analysis is not straightforward, because ISO standards are often used directly in the United States, rather than being formally adopted by many other countries as national standards. Nonetheless, direct use of an ISO or IEC standard is genuinely global harmonization in the best sense. The analysis should determine: the extent to which ISO standards are used directly; the extent to which they are formally adopted as U.S. standards; the extent to which U.S. standards (such as ASME, ASTM, IEEE, NFPA, etc.) are used as global, regional (foreign) or local (foreign) standards; and the extent to which U.S. standards are isolated from the international scene.

With assistance of Commerce's International Trade Administration (ITA), NIST should determine the extent to which foreign monies are spent to get standards in developing nations harmonized to particular local, regional, or international standards. For example, the European Union has authorized significant EC monies to CEN and CENELEC to get Central and Eastern Europe to adopt EC directives as part of their national standards systems. Similar efforts are underway at the national level, particularly by Germany and Japan. The amount of money (and time) spent by the United States is trivial by comparison. This analysis should compare the funds expended for the various tasks in standards and conformity assessment by the United States and other international players.

Finally, NIST should determine the extent of funding (both public and private sector) for U.S. policy and technical participation in and support of international standards efforts. Current support is often diffuse and uneven. It is vigorous in some areas. For example, the U.S. TAG to ISO 207 has about 500 members, but other ISO committees have no or only token U.S. participation. Because U.S. participation is not directly supported financially by government, ANSI, or the SDOs, the United States is not always represented at all committee meetings, does not participate regularly, or is not represented effectively by the appropriate technical/policy expert. Spotty, intermittent attendance is not the way to participate effectively in a standard's development, or influence its outcome. In conjunction with ANSI which has begun this analysis for the U.S. voluntary sector, the NIST analysis should focus on the extent to which the United States participates in ISO/IEC committees (as well as OIML, BIPM, Codex Alimentarius Commission, UNECE, OECD and other government treaty organizations); examine attendance records and voting positions; and provide recommendations for appropriate financial and policy support.

The analyses identified in this section will provide the input needed for recommended changes. They will enable us to work with the standards constituency to identify and implement reasonable policies for a more effective U.S. voice in the international arena, and explain some of the costs and disadvantages of the current fragmented approach.

Federal Agency Coordination

Regulatory harmonization is rapidly becoming a major international issue in concert with standards harmonization. Achieving regulatory harmonization will require continuing government-to-government discussion (such as the EU-MRA discussions) in specific regions of the world. A critical issue is that products regulated in one country might not be regulated in another country. For example, building products are regulated in Japan, but largely covered in the private sector in the United States. Regional discussions are now going on at the governmental level: with the European Commission and through the industry-to-industry discussions in the Transatlantic Business Dialogue; with the Americas under the auspices of the Free Trade Area of the Americas discussions; and with Asia through the Asia-Pacific Economic Cooperation.

As with harmonization of standards, coordination on regulatory policies and supporting procedures is needed among Federal agencies. The ICSP must take a stronger role in coordinating U.S. regulatory approaches and policy issues across Federal agencies. Agencies must coordinate activities where there is overlapping impact on trade, and on the technical infrastructure for conformity assessment needed to facilitate trade. NIST is working with Federal agencies to strengthen the ICSP as a coordinating body of Federal agencies for developing effective standards- and conformity assessment-related policies. Each agency must develop and implement a strategy that sets priorities and integrates use of voluntary standards to overall agency objectives. Strategies will differ among agencies for regulatory, procurement, and trade purposes, with some competing interests that must be reconciled through interagency coordination.

NIST will continue to work with other Federal agencies to provide technical support in fora aimed at government-to-government harmonization of government regulations and voluntary standards. This includes participation in the UNECE Working Party on Regulatory Harmonization and Standards (formerly the Standards Working Party). This group, which has recently expanded its scope into the regulatory arena, is one of the few fora where experts from Central and Eastern Europe as well as the Commonwealth of Independent States meet with counterparts from Western Europe and the United States.

In conjunction with OMB, NIST will develop mechanisms to collate inputs from Federal agencies regarding their participation in private sector standardization activities and reliance on private sector conformity assessment mechanisms. NIST is also working with OMB to revise OMB Circular A-119 to document NIST's new responsibilities for conformity assessment, and to suggest mechanisms for greater coordination on standards policies. In addition, the ICSP will request input from agencies on their use of voluntary standards to replace or supplement agency regulations, their relationships with the private, voluntary standards community, and any policy changes required to implement the Technology Transfer and Advancement Act. The ICSP and its member agencies must develop a standards-based culture within each agency, with supporting strategic plans. They must also develop strategies for addressing cross-cutting issues. Specific steps should be taken regarding activities led by the ICSP, by individual agencies, and/or by the private sector. While NIST is responsible for overall leadership and guidance, it cannot accomplish the national standards goals without the active cooperation of other Federal agencies and the private sector.

Finally, NIST will continue to emphasize efforts to make the ICSP a viable and effective forum for coordinating federal efforts in both standards and conformity assessment, and for encouraging and documenting agency use of private sector voluntary standards. NIST will also work vigorously with the states and localities in standards and conformity assessment activities to achieve the goal of a national system or systems that will be recognized and accepted worldwide. All these efforts will require active cooperation among federal, state and local governments with the private sector in an effort to build systems that support U.S. trade while maintaining high standards of safety, health, and the protection of the environment.

Meeting the Standards Challenge of the Global Market

A key issue for entities concerned with standards in the United States is: can our fragmented, dog-eat-dog, frontier-type "system" survive in a world where cooperation and harmonization are increasingly the mode of operation? NIST remains committed to working with ANSI as the U.S. member body to ISO and IEC (through the national committee) and as the prime coordinator of private sector standards activities. ANSI's position as the coordinator for the voluntary standards system must be strengthened while allowing each SDO to retain its position as major standards developer in a particular sector or sectors. At the same time, ANSI's role as focal point and facilitator of the U.S. voluntary standards system must be recognized and strengthened. NIST must work with other U.S. Federal agencies to determine the U.S. Government's "fair share" of ANSI's funding. A sound financial footing is essential for ANSI to serve as the U.S. standards coordinator, accreditor of standards developers, and representative to voluntary international standards organizations. These activities are truly a matter of public policy; we must reinforce ANSI's position without dominating decision making. Federal agencies need to become an active, effective part of the ANSI Federation, using the voluntary standards process appropriately to carry out or supplement agency missions. This Federal agency participation must extend to the international arena in standards and conformity assessment policy and in standards committees.

A key step in meeting these challenges is a joint study by a combined team of NIST, ANSI, SDO's, and U.S. regulatory and procurement agencies. This study should address the need for giving some sectors (e.g., computers and telecommunications) priority support due to their rapid technological changes, as well as the need for support to older, established technologies and industries. The study must address our standards priority setting in general, as well as any focus on particular regions of the world. NIST, ANSI, and other players in the standards system must provide strong policy and strategic support, as well as active participation in key international policy organizations such as ISO-DEVCO (Developing Nations Committee), INFCO (Information Committee), REMCO (Reference Materials Committee) and Conformity Assessment Committee (CASCO), as well as ISO 9000, 14000, and other cross-cutting management system standards. Foremost, however, is the need to "get our act together" domestically so that we can meet the international challenges effectively and rapidly.

It is imperative that NIST and the ICSP develop mechanisms for federal coordination with the private sector, including ANSI, to stimulate more effective interaction with ISO and IEC. An important first step is for NIST and the ICSP to convene a public forum to discuss the issue of international standards and U.S. interests. This forum must address frankly the issues of national voice, financial stresses, and public benefits. In addition, the ICSP must examine the need, and reasonable means for, increasing federal financial support for the U.S. voluntary standards system, particularly to support U.S. participation in ISO and IEC. (The ANSI dues for these two organizations are about $2M; the Federal Government's share is approximately $30K.)

Conclusion

It is clear that U.S. government agencies and private sector interests must develop an improved, workable standards process for the United States that will enable us to respond to the challenge created by the global market. We must work together to build domestic structures that support us effectively internationally. NIST is committed to working with other government agencies and the private sector to develop and implement a process that meets the needs of industry, regulators, and standards developers. In the end, we will build together an effective standards process that will contribute to a strengthened economy and improved international trade, while protecting health, safety, and the environment.

VI. Develop Conformity Assessment Processes

James L. Cigler*

Abstract

The rapidity with which technological change is occurring in many industrial areas, combined with escalating globalization of U.S. trade, has increased the need to standardize various aspects of the marketplace and to ensure conformance to standards. Conformity assessment is defined as "any activity concerned with determining directly or indirectly that relevant requirements are fulfilled." Three activities collectively make up what is generally referred to as conformity assessment: product certification (includes sampling and inspection); laboratory accreditation of testing and calibration laboratories; and quality system registration. Conformity assessment has a great impact on trade in both domestic and international markets as reflected in international standards and their development, recognition of competent parties to perform conformity assessment activities, and the ultimate goal of ensuring the quality of consumer and safety needs. Conformity assessment activities are a vital link among normative standards, product requirements, and the products themselves. NIST plays a major role in these areas as the national measurement laboratory and measurement research institute.

Background

The extent of the impact of conformity assessment activities is evident when one considers specific product examples. A state-of-the-art computer is of no benefit without compatible software. A new and technologically superior appliance is useless if its plug does not fit the outlet; or (worse yet) appears to fit, but actually increases the potential for fire or electrical shock. Nor does one want to purchase a product or service that appears to meet one's needs and then discover that it has inherent and undetected defects. If we purchase products or services on a regular basis, we don't want to find that they are periodically unacceptable due to variations in their production or delivery processes.

Conformity assessment is defined in ISO/IEC Guide 2 as: "any activity concerned with determining directly or indirectly that relevant requirements are fulfilled." Conformity assessment procedures provide a means of ensuring that the products or services produced have the required characteristics, and that these characteristics are consistent among products of the same kind or from service to service. Conformity assessment activities include: product certification (includes sampling and inspection); laboratory accreditation of testing and calibration laboratories; and quality system registration.

Some product and service characteristics are vital for safe and effective performance, and many of these characteristics cannot be assessed simply by picking up and examining the product in the marketplace. Such characteristics need to be determined through the conformity assessment process.

The impact of conformity assessment on trade in both domestic and international markets was noted prominently in the 1994 Agreement on Technical Barriers to Trade (TBT Agreement) of the international General Agreement on Tariffs and Trade (GATT) of the World Trade Organization (WTO). The TBT Agreement recognizes that conformity assessment activities can expedite or seriously hinder the free flow of goods in international commerce and establishes procedural requirements for conformity assessment schemes to avoid the establishment or continuance of unnecessary obstacles to trade. The Agreement requires that conformity assessment procedures be "prepared, adopted and applied so as to grant access for suppliers of like products originating in the territories of other Members [WTO members] under conditions no less favorable that those accorded to suppliers of like products of national origin or originating in any other country... ." It also requires that such procedures not be "prepared, adopted or applied with a view to or with the effect of creating unnecessary obstacles to international trade."

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A major international goal must be the development of internationally agreed-upon procedures for each element of the conformity assessment process. Domestic recognition of competent parties to carry out these procedures is an essential element of this technical infrastructure. Ideally, a properly designed and conducted conformity assessment program benefits, not hinders, the free flow of goods. Conformity assessment can verify that a particular product or service meets a given level of quality or safety, and can provide the user with explicit or implicit information about its characteristics, consistency of those characteristics from product to product or service to service, and/or performance of the product/service. Conformity assessment can also increase a buyer's confidence in a product/service.

Conformity assessment activities form a vital link between normative standards, which define the necessary characteristics or requirements for such products/services, and the products/services themselves. As such, all three---the product/service, the standard(s) for the product/service, and the conformity assessment process---are interrelated. This chapter discusses some of the issues involved in each type of conformity assessment activity, interrelationships among these activities, and some topics regarding the standards used. It also covers the impact that each activity can have on the degree of confidence in the output of the conformity assessment process.

Areas of U.S. Concern

Chief areas of conformity assessment concern to U.S. industry and Federal agencies include: 1) international recognition of U.S. laboratory testing and accreditation; 2) international acceptance of U.S. quality system registrations; 3) international acceptance of U.S. product certification, and 4) U.S. calibration and standard reference material (SRM) services.

Chief Areas of Conformity Assessment Concern To U.S. Industry and Federal Agencies

- International recognition of U.S. laboratory testing and accreditation
- International acceptance of U.S. quality system registrations
- International acceptance of U.S. product certification
- U.S. calibration and standard reference material (SRM) services

Figure 6.1

Laboratory accreditation is often performed by a third party (public or private sector) accrediting body, and is intended to make a determination that a testing or calibration laboratory is competent to perform the services which it offers to its customers. Second party (buyer) accreditations, often confused with audits or vendor qualification inspections, are not recognized internationally; the ability of a buyer to evaluate a supplier's competency is often questioned, because the buyer normally has no formal program or training in the accreditation process.

Quality system registration usually refers to the assessment of a supplier's quality system against one of the quality system models described in the ISO 9000 Standards Series. The ISO 9000 standards were originally written for use by third party assessors in procurements, but are now widely used by buyers in a second party sense as part of contractual requirements. The quality system in place may be intended to drive production of either goods or services. The advent of ISO 14000 standards is rapidly attracting attention for the assessment of environmental quality systems. The focus of quality system registration programs such as these is the validation of a documented system process that satisfactorily addresses the specific quality or environmental process elements described in the standards.

Product certification is the inspection and testing of product(s) to ensure conformance with a performance or design specification. It may result in placement of a mark on the product(s), such as the familiar Underwriters Laboratories UL identification or the Good Housekeeping Seal of Approval, or the issuance of a certificate of approval to indicate compliance with accepted standards. This has become a topic of great discussion as the United States negotiates with the European Union (EU) for mutual recognition agreements for regulated products.

The *U.S. Calibration and Standard Reference Materials Services* are critical to the conformity assessment process. Test and calibration data used to determine compliance with standards must be based on measurements that are traceable to national calibration or reference material standards ultimately based on the international system of units (SI). There must be an ongoing effort to ensure that the U.S. national laboratory (NIST) continues to provide calibration and measurement services that are accepted internationally. This topic is treated in more detail in Chapter III.

Background To U.S. International Conformity Assessment Challenges

The U.S. approach to conformity assessment has emphasized the concepts of self-declaration of either products or services and second party verification as a contractual requirement. There are instances of requirements for product marking where consumer safety has been a concern, and governmental regulatory programs have focused on ensuring that public safety and health standards are maintained. The U.S. "system" can best be described as one of considerable decentralization among public sector (federal and state government) and private sector conformity assessment bodies. In contrast, the vast majority of other countries centralize conformity assessment activities under the government or a private sector entity recognized by the government. Little, if any, competition is allowed in conformity assessment in foreign countries---the significant difference between the United States and foreign countries that causes serious problems in negotiating international trade agreements.

Product Certification

Product certification involves the inspection and testing of product(s) to verify that they meet the standards which relate to their production. As already stated, with the exception of regulatory requirements, the U.S. approach relies on a supplier's self-declaration that his product conforms to the relevant standards or certification programs operated within the private sector. Third party private sector certification programs are operated successfully for technical and fire safety by such certification bodies as the Underwriters Laboratories (UL), Factory Mutual Research Corporation, and MET Electrical Testing Company. While these have become accepted as "nationally recognized testing laboratories, or NRTLs" for workplace safety, they existed long before the Occupational Safety and Health Administration (OSHA). Furthermore, their certifications are widely recognized by consumers as marks to look for when buying consumer products. Consumer protection is also afforded by the U.S. legal system, which holds a manufacturer liable for problems related to the safety or performance of the product.

With the advent of regional economic unions such as the EU, and the Asia Pacific Economic Community (APEC), the issue of international trade in regulated products has become a major point of discussion. The U.S. Government is currently negotiating agreements with the EU in the areas of exported, regulated products, and the subject of product certification by the EU's governmentally designated bodies, referred to as "notified bodies," are at the forefront. NIST issued a Federal Register Notice (Vol. 61, No. 89, May 7, 1996) requesting information from U.S. organizations that believe they can perform certification of products that might enter the EU in the areas of telecommunications terminal equipment (TTE), electromagnetic compatibility (EMC), low voltage electrical equipment (LVD), and recreational craft. Responses will assist in the potential designation of the equivalent of "notified bodies" in this country. Since the U.S. system of product certification is quite different from those in foreign countries, considerable effort will be required to get these countries to accept our system.

Quality System Registration

In the United States there are approximately 50 private sector registrars performing ISO 9000 quality system registrations.[1] Many of these are certified by the American National Accreditation Program for Registrars of Quality Systems (ANAPRQS) under the auspices of the Registrar Accreditation Board (RAB) and American National Standards Institute (ANSI). Requirements for U.S. companies to have their quality systems registered to ISO 9000 are growing every day, due in part to the increasing demands from the international market place and increasing inclusion in contract language inspired by the total quality management (TQM)

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[1] Breitenberg, Maureen A., The ABC's Of The U.S. Conformity Assessment System, Draft NISTIR.

movement in the United States. There is also a trend for U.S. government agencies to embrace use of commercial normative standards, including ISO 9000, as part of the government procurement process. The recognition of ANAPRQS or the ANSI-RAB program by the international quality system registration community will depend in large part on the direction that the United States takes in coordinating its conformity assessment activities.

United States Laboratory Accreditation

The U.S. "system" of laboratory accreditation has evolved over many years with no true government coordination. Federal regulatory agencies started programs for accrediting testing laboratories in public safety and health, and today there are numerous programs in agencies such as the Food and Drug Administration (FDA), Federal Highway Administration (FHA), and Occupational Safety and Health Administration (OSHA). There are also many private sector accreditation programs such as the American Association for Laboratory Accreditation (A2LA) and ETL Testing laboratories, Inc. which developed to ensure competency in testing laboratory operations in such products as doors, windows, electrical appliances, insulating materials, medical products, and so forth. By some estimates, there are between one and two hundred public and private sector laboratory accreditation bodies in the United States with no system of recognition or approval by the Government. This is a major concern by other nations which, as a rule, restrict laboratory accreditation responsibilities to a single body or a group of bodies recognized by the Government.

In 1976, the National Bureau of Standards (NBS, now NIST) established the National Voluntary Laboratory Accreditation Program (NVLAP). Early NVLAP accreditation programs were established in the testing laboratory community, mostly at the request of federal regulatory agencies. In 1988, a program was developed to accredit asbestos testing laboratories. This was mandated by the Asbestos Hazard Emergency Response Act (AHERA), and continues today as a major NVLAP program. Other NVLAP programs have been developed at the request of federal regulatory agencies, such as the Nuclear Regulatory Commission (NRC) for dosimetry processing laboratories, the Department of Energy (DOE) for energy efficient lighting laboratories, and the Department of Housing and Urban Development (HUD) for carpet testing laboratories. NVLAP has also developed programs when requested by private sector organizations such as the National Conference of Standards Laboratories (NCSL). The program for the accreditation of calibration laboratories was requested by NCSL and started in May of 1994. NVLAP maintains an active accreditation program for over seven hundred testing and calibration laboratories and participates with other NIST staff in international standards development, national standards development, standards information, and training activities. By its own operating procedures, published in the U.S. Code of Federal Regulations (Part 285, Title 15), NVLAP offers programs only where required by law, at the request of other government agencies, or when requested by the private sector in areas where a need is clearly demonstrated and where not already available in the public or private sector. NVLAP's scope of accreditation services is therefore limited.

Problems

Laboratory Accreditation. The major problem in conformity assessment in the United States stems from the highly decentralized nature of the U.S. system. Countries, or geographic regional associations such as the European Cooperation for Accreditation of Laboratories (EAL) and the Asia Pacific Laboratory Accreditation Cooperation (APLAC) have government-led systems, and want us to have a single focal point for government-to-government mutual recognition agreements. Accordingly, we are faced with the problem of gaining consensus among the hundreds of public and private sector accreditation bodies to operate in accordance with international standards, and for accreditors, their customer laboratories, and the customers of those laboratories to recognize that competent programs operating in similar areas (e.g., water quality testing programs operated in several states and accredited by the individual state authorities) are equivalent. This is the task of the Laboratory Accreditation Working Group (LAWG), sponsored by NIST, ANSI, and ACIL (formerly the American Council of Independent Laboratories) which has proposed a public/private entity (tentatively called NACLA , an acronym for the National Council for Laboratory Accreditation) to help achieve recognition of laboratory accreditation nationally and internationally.

Another problem relates to recognition of national measurement services by the national measurement institutions (NMIs), their customers, accreditation bodies, and government regulators. Recognition by accreditors and laboratory customers of the equivalency of laboratory accreditations in this country and abroad implies that traceability of measurements to the national laboratories in foreign countries is also accepted. This can be achieved only through agreements among the NMIs of each country involved (NIST in the United States). Similarly, U.S. regulatory agencies, such as the Federal Aviation Administration (FAA), require measurements that are made as part of maintenance actions on U.S. aircraft in foreign countries be traceable to NIST. Reliance on foreign accredited laboratories which maintain traceability to their countries' NMIs could be obtained if there were better documentation of national measurement equivalence agreements between the NMIs and the accrediting bodies. This is a major problem in the developing nations of South and Central America, and is being addressed through training seminars and workshops sponsored by the NIST Calibration Program in this country and in the Americas. Equivalency of measurement services at the national laboratory level is a major focus of groups of national laboratories in organizations such as the North American Metrology Program (NORAMET), the European Metrology Program (EUROMET), and the Asia Pacific Metrology Program (APMP). Achieving international agreement on measurements is also a goal of the Organization of International Legal Metrology (OIML).

Product Certification. Expansion of international trade has led to increased foreign concerns with the U.S. system of product certification. Global trade negotiations between the United States and the EU are surfacing questions about the methods by which U.S. manufacturers certify their products. The areas of concern include: 1) the confusing U.S. system of self-declaration, often unacceptable in the international arena; 2) lack of the use of accredited laboratories as a source of test data; 3) the large numbers of redundant, performance-based and design standards used to certify the same products in this country and abroad; and 4) the variability of program procedures and policies among U.S. certification programs.

Quality System registration. With respect to ISO 9000, the major problem is the lack of an internationally recognized accreditation program for registrars in this country or elsewhere. A U.S. company wishing to do business in a foreign country must carefully select a registrar whose registration will be accepted in that country. Registrars in the United States, certified by ANSI-RAB, are seldom recognized in the international arena as there are no international mutual recognition agreements between ANSI-RAB and foreign registrar accreditation bodies. In many instances, U.S. companies have been informed by European buyers that access to the European market requires registration by a registrar accredited in Europe. There is also great concern in this country with the qualifications of U.S. registrars and their competency to ascertain whether or not the quality system in question is acceptable by ISO 9000 standards.

In addition, the areas of quality system registration and laboratory accreditation overlap and there are different customer, regulator, and product specifier preferences with respect to which process is preferred to assure competency in testing or calibration laboratories. Finally, there are emerging problems in the registration of environmental management systems using ISO 14000, with a U.S. position still being formulated.

The NIST Mission Includes

- Technology transfer
- Coordination of Federal Agencies in use of commercial standards
- Technical support for U.S. industry
- Maintenance and operation

NIST Approaches

A. Work toward mutual recognition agreements in laboratory accreditation

B. Provide technical support in international trade negotiations on technical barriers to trade

C. Expand role in development of international standards

D. Coordinate development of a public/ private entity to recognize U.S. laboratory accreditation bodies

Figure 6.2

Why Should NIST Be Concerned?

One of NIST's missions is technology transfer. The recent passage of the National Technology Transfer and Advancement Act of 1995 has reconfirmed and strengthened NIST's role as a coordinator of the Federal agency movement toward the use of U.S. commercial and international normative standards and away from developing new federal specifications and standards. U.S. domestic and international activities in conformity assessment have a positive effect on U.S. industry competitiveness and without a strong technological measurement infrastructure which can be related to national standards there can be no basis for assessment of product conformance to specifications.

NIST supports the U.S. Trade Representative and Department of Commerce trade agreements negotiations under the framework of NAFTA, WTO, and other fora. NIST is the appropriate agency to spearhead technical efforts in standards and conformity assessment aimed at reducing barriers to trade.

Approaches

A. NIST will continue to work toward mutual recognition agreements (MRAs) in the area of laboratory accreditation, especially on a national, and ultimately international, basis where such government involvement in laboratory accreditation is required by the trading partner. Agreements will be sought with regional groups such as EAL, APLAC, and NACC, but will also be undertaken bilaterally with individual countries as the situation warrants. NIST will work toward implementation of NACLA to serve as the focal point for U.S. efforts to bring coherence to the U.S. domestic system and its recognition internationally.

B. NIST will provide more technical support to U.S. negotiations with the EU, NAFTA, and other regional organizations regarding technical barriers to trade, and expand training seminars in the United States.

C. NIST will play an expanded role in international activities to develop normative standards for conformity assessment procedures. Greater worldwide acceptance and adoption of international normative standards will reduce barriers to trade that arise from redundant conformity assessment activities due to different requirements in various countries where business is sought.

D. NIST will play a key role in developing one or more public/private entities to unify conformity assessment activities in the United States. With U.S. Government recognition, this will facilitate acceptance worldwide of U.S. conformity assessment data. The Interagency Council on Standards Policy (ICSP) chaired by NIST, along with its working groups, will help coordinate the activities of government agencies in this area, as well as helping to set policy in standards, and accreditation of laboratories and in other conformity assessment activities. (See Chapter V.)

E. Through its National Voluntary Conformity Assessment Systems Evaluation Program (NVCASE), NIST will support quality systems registration in the ISO 9000 and ISO 14000 arenas. NIST will also seek to incorporate the U.S. accreditation of registrars in both arenas into a public/private sector oversight body. In the product certification arena, this oversight body, ideally, will recognize those who accredit product certifiers---or less ideally, those who certify product(s).

F. NIST will increase its long term training role in the international arena. Many emerging economies are potential U.S. trading partners, but have yet to develop the necessary infrastructure for standards and conformity assessment.[2] NIST can help these nations establish that infrastructure through training workshops and seminars on the development and use of standards and conformity assessment. (Chapter IV contains details.)

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[2] ASME International, The Impact of Government Budget Changes and Restructuring on Engineering, ASME, and the Public, April 1996, pp. 17-25.

G. NIST will also expand its role with U.S. industry in promoting national and international standards for conformity assessment. Topics for workshops and other outreach programs include: 1) use of performance versus design standards for conformity assessment; 2) product certification in the United States and abroad; 3) laboratory accreditation programs in the United States and abroad; 4) registration of quality systems in the United States and abroad, and 5) development of innovative procedures for ensuring conformity to performance standards.

Summary

The U.S. system for conformity assessment is complex, multifaceted and comprised of many diverse activities including: testing, certification, quality system registration, accreditation and accreditation program recognition. These activities are distinct operations, but are closely interrelated. The inclusion or absence of any of them, as well as the quality with which each is performed, can have a significant effect on the confidence and reliance placed on the results of the overall conformity assessment process. In addition, the normative standards that underlie each of these activities can also have a major impact on the outcome of each and a cumulative effect on the whole.

Together, standards and conformity assessment activities affect almost every aspect of life, and the ability of U.S. industry to compete effectively in the global marketplace. Conformity assessment is important for marketplace communications---a means of exchanging information between buyer and seller about the ability of a product to conform to a standard. Buyers, sellers, and other interested parties therefore must understand the conformity assessment process, judge the value of a particular assessment scheme, and use the resulting information to make intelligent choices. The quality of the information conveyed depends on: the impartiality and competence of the assessment body; the types of assessment activities included in the scheme; and the adequacy and appropriateness of the standards against which the product or service is evaluated.

Poorly performed conformity assessment may result in buyer deception, inadvertently or deliberately, if the performance characteristics or test methods contained in a standard are insufficient to ensure adequate product/service performance, or if the buyer is misinformed as to the competency of the conformity assessment body or the extent to which the product/service characteristics have been evaluated. By contrast, properly conducted conformity assessment furnishes valuable information to the marketplace and can facilitate and enhance opportunities for trade. The United States and its trading partners must work toward mutually agreed upon systems of conformity assessment to facilitate the free flow of goods across international boundaries.

NIST has a major role to play in supporting the U.S. conformity assessment process as the national measurement institution in this country. To quote the words of John Quincy Adams, "Weights and measures may be ranked among the necessaries of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce; to the labors of the husbandman; to the ingenuity of the artificer; to the studies of the philosopher; to the researches of the antiquarian; to the navigation of the mariner, and the marches of the soldier; to all the exchanges of peace, and all the operations of war. The knowledge of them, as in established use, is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is riveted in the memory by the habitual application of it to the employments of men throughout life."

Without weights and measures, including the standards by which products and services are assessed, there is no basis for determinations of acceptability. It is NIST's mission and obligation to ensure that there are appropriate standards of measurement.

VII. Support U.S. Foreign Policy Objectives

B. Stephen Carpenter*

Abstract

International science and technology (S&T) cooperation is often an integral part of U.S. foreign policy, particularly with countries where there are significant cultural differences and where trade and economic issues are challenging. S&T cooperation can enhance vital linkages that promote goodwill and can often advance a specific U.S. policy objective with a specific country. S&T is an effective means through which the United States can encourage political changes and economic growth in a country or region and it is in our interest to take advantage of our position as a leader in S&T and to use it effectively to promote U.S. interests abroad. And, as described in other chapters of this report, such S&T cooperation contributes directly to the NIST mission. NIST researchers have developed collaborative relationships that have created a significant stimulus for new measurement capability and new standards, and have made it easier to adopt a consistent measurement and standards system.

Background

Historically, international science and technology (S&T) cooperation has been used as an instrument to promote U.S. foreign policy objectives. This is true for a variety of reasons. When cultural differences are vast, and trade and economic issues appear insurmountable, science and technology cooperation is often the least controversial mechanism available to project the U.S. position abroad. S&T cooperation can enhance vital linkages between public and private researchers and educators in the United States and those in other countries. These unique linkages can promote goodwill with the general public and policy makers, and can often be used to advance a specific U.S. policy objective with a specific country.

An example is protection of intellectual property rights. As a result of the 1988 Omnibus Trade and Competitiveness Act, the U.S. Government is now required to consider the protection of intellectual property in all its S&T relationships. The United States, recognizing increasing infringement of U.S. patents and copyrights from foreign countries, wanted to utilize any and all means to make other countries aware of the urgent need to provide adequate and effective protection for intellectual property. This is true not only with countries that do not currently protect intellectual property, but also with developed countries that may not have considered this an important component of foreign policy and S&T cooperation. In addition, the United States recognized the potential for loss of intellectual property developed in the course of international scientific and technical exchanges, and needed a mechanism to provide for its protection. Because formal S&T agreements are highly regarded in many foreign countries, the United States developed the strategy of using S&T agreements to leverage better intellectual property protection abroad. Unfortunately, this has not always been successful. In China, for example, after years of negotiation, the United States and China did reach agreement on protection of intellectual property in our S&T relationship. This, however, has not reduced cases of Chinese infringement of U.S. patents and copyrights, which recently resulted in the threat of U.S. trade sanctions against China.

S&T cooperation also is an effective means through which the United States can encourage political changes and economic growth in a country or region which, in turn, can benefit the United States. The United States recognizes that foreign countries still look to us as a leader in most scientific and technical fields. Through the establishment of official S&T relationships, foreign countries hope to gain access to and participate in on-going R&D activities in the United States in order to improve their own scientific and technical base, strengthen linkages for their research professors, and hopefully stimulate domestic economic growth. That growth creates a market for U.S. trade and investment.

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The NIST mission also benefits by participation in these S&T arrangements. NIST has the unique responsibility to assure that U.S. industry has access to the measurements and standards that it needs to compete in a global market. Because advancing technology is a significant stimulus for new measurement capability and new standards, NIST maintains a world class research and development program to support emerging measurement needs. These new capabilities generally are first available within the country in which the advances are made, so it is important that the United States maintains a leadership role, and that customers and suppliers quickly gain access to new metrology in the global market. In addition, NIST's measurement capabilities help to support U.S. regulatory agencies in their effort to ensure the health and safety of U.S. citizens abroad. NIST targets participation in international conferences and international standards committees in those areas in which U.S. industry needs a broader metrology base than that which currently exists. When NIST scientists and engineers have worked with their counterparts from other countries in the development of measurement science supporting the new measurement capability, it is generally easier to adopt a consistent measurement system.

NIST's Role in Bilateral and Regional Activities

People's Republic of China

In the 1960's when the United States was opening its doors to the People's Republic of China, one of the very first formal arrangements was the establishment of a cultural and educational exchange program. From this exchange program, a Science and Technology Agreement was born which involved (and still involves) almost all of the U.S. government technical agencies. While many of these arrangements were created initially for political reasons, most have prospered into mutually beneficial cooperative programs. Not only did the United States benefit from the scientific expertise of researchers from China who came to work in U.S. facilities, the U.S. Government's objectives of enhancing the U.S. position in China, gaining access for U.S. researchers into Chinese facilities and research centers, and promoting Chinese access to the western world were also met. Thus, through this S&T program, the United States has an entre into China's research community. While the U.S. relationship with China has had its ups and downs, especially following the events of Tiananmen Square in 1989, the S&T relationship has continued to grow.

NIST's cooperation with China focused initally on scientific exchanges with the Chinese State Bureau of Technical Supervision, but over the years this cooperation expanded to include several research institutions in China. Despite U.S. concerns regarding the protection of intellectual property in our S&T relationship, mutually beneficial cooperation remains an important component of the U.S. relationship with China. For example, scientific exchanges are still encouraged and, at NIST, large numbers of Chinese researchers continue to participate in NIST's Foreign Guest Researcher Program. One area that the United States regards as very promising for cooperation is materials science. In 1995, the Director of the NIST Materials Science and Engineering Laboratory led a U.S. delegation to China to explore opportunities for cooperation in that field. A Chinese delegation reciprocated this past summer (1996) and discussions are underway on future areas for cooperation. This type of cooperation not only supports the U.S. objective of maintaining our scientific ties with Chinese researchers, but also may provide unique opportunities for first class research results.

India

Another example of an S&T program that was established to promote goodwill is the U.S.-India S&T Program. Cooperation began in the late 1950's with U.S. and Indian scientists collaborating on agricultural research projects supported by P.L. 480 funds (non-convertible rupees) from the sale of U.S. agricultural commodities to India. In the early 1960's, the U.S. Agency for International Development (U.S. AID) began to expand the collaboration to other areas of science and to improve the educational system in India by assisting in the establishment of the Indian Institute of Technology at Kanpur. Then, several U.S. technical agencies, such as the Department of Health and Human Services, the National Institute of Standards and Technology, and the Smithsonian Institution, initiated a number of projects funded with PL-480 rupees. In 1974, as the science and technology collaboration increased and became a major element in broadening the relationship between the two countries, then Secretary of State Henry Kissinger and Minister of Foreign Affairs B. Y. Chavan, signed an agreement to establish a Joint Commission with Subcommissions for Science and Technology, for Education and Culture, and for Economics and Commerce. During that same year the U.S. Government returned more than half of the PL-480 rupees to the

Government of India and agreed to use the remainder of the U.S.-owned rupees to collaborate on science, technology, education and cultural activities. U.S.-India science and technology cooperation was enhanced and gathered more political weight and commitment from both sides when the Science and Technology Initiative was signed in 1982 by the U.S. President and the Indian Prime Minister. In 1987, this collaboration was raised to a new level when both governments signed the agreement establishing the United States-India Fund (USIF). NIST has played an integral role in the U.S.-India science and technology collaborations, and currently has 25 active projects under USIF.

NIST has used this collaboration to improve measurement capability. For example, NIST staff collaborated with scientists in India to develop an improved model for the propagation of light through optical fibers. The information gained was disseminated to U.S. industry through, for example, short training courses on optical fibers. Today, U.S. fiber suppliers are major players in the world market, and measurement standards used worldwide are consistent with U.S. domestic standards.

Japan

Japan is the second largest economy in the world, our second largest trading partner, and our leading trading partner in high technology products. Yet, our bilateral trade deficit with Japan is still the largest that we have with any nation. Japan is the leader in its part of the world for innovations in science and technology. For over three decades the United States and Japan have collaborated in a growing range of S&T areas. Much of this collaboration has been mutually beneficial. On March 14, 1996, Robert Hebner, Acting Deputy Director, NIST and Hajimo Irisawa, Executive Director, Japanese Real World Computing Partnership (RWCP), signed an agreement to undertake a Joint Optoelectronic Project between NIST and RWCP of Japan's Ministry of International Trade and Industry. Under the RCWP, NIST functions as a broker in facilitating connections between the user who has a novel design, and the suppliers who perform fabrication. This is a promising attempt at the mutually beneficial exchange of precommercial technical information. In March 1996, NIST participated in the U.S.-Japan Panel on Fire Safety. The objectives of the panel, established in 1975, are to: encourage, develop, and implement the exchange of information and data in fire and smoke physics, toxicity, chemistry, and risk and hazard evaluation; promote cooperative research in areas of fire safety and combustion toxicity; encourage innovations in risk assessment methods, fire test methods, and design standards; establish a multi-national consensus of computer-based fire modeling; develop performance fire codes; and develop new fire protection and prevention technology appropriate to modern products and design. The Japanese sent a delegation of 25 scientists for the 1996 meeting, and the United States had 48 participants including many NIST staff.

Harmonization of standards is an increasingly critical issue. Although standards can facilitate international trade by making transparent the technical thresholds that must be met, standards also can be used as barriers to trade. In 1995, for example, a Japanese standards organization announced its intention to impose requirements for certification that would have resulted in the disclosure of proprietary software data by U.S. exporters. An example of using S&T to further U.S. foreign policy objectives such as harmonization of standards to facilitate trade is NIST work with the National Aerospace Laboratory (NAL)/Kakuda Research Center in Japan. NIST has signed an MOU with NAL to compare measurement techniques for the thermal conductivity of functionally graded materials (FGMs) and graded ceramic coatings intended for a wide range of aerospace and industrial applications. In March of 1996 NIST signed an agreement with the Communications Research Laboratory of Japan to pursue a contractual arrangement to construct and evaluate an optically pumped primary frequency standard.

South Africa

Another example of S&T in support of U.S. foreign policy objectives is the United States-South Africa Science and Technology Agreement which was signed under the auspices of the Gore-Mbeki Economic Partnership. The United States is a strong supporter of the democratically elected government of South Africa and remains committed to assisting the South African Government in economic development. The U. S. policy has been to explore opportunities for cooperation in areas that will promote infrastructure development and provide opportunities for the previously disadvantaged population. By providing opportunities for cooperation the Gore-Mbecki Initiative is expected not only to enhance government-to-government scientific cooperation, but also to promote more opportunities for U.S. industry in South Africa and throughout the southern African region.

NIST has been working with its counterparts in South Africa under the S&T Agreement, and has developed and signed a Memorandum of Understanding (MOU) with South Africa's CSIR which is the agency responsible for competitiveness, technology for development, and technology for decision making. The initial focus of this MOU is to explore cooperation in the areas of building, construction, and advanced materials. This MOU could serve to promote NIST's interest in the entire south African region since the CSIR has become the "Gateway Metrology" laboratory for that region. Thus, if NIST is successful in ultimately establishing some level of equivalency between measurements at NIST and measurements at CSIR, NIST can take advantage of the local activities in Africa to assure a broader measurement consistency. NIST has begun developing linkages with the region through visits and workshops that have been very successful, especially the regional workshop on "The Use of Standard Reference Materials for Chemical Metrology" held in Harare, Zimbabwe in 1994.

The Americas

The United States also has used S&T cooperation as a means to promote regional efforts in the Americas. A key example is through the North American Free Trade Agreement (NAFTA). Under this regional pact, Canada, Mexico and the United States established metrology systems to underpin most industrial and trade activities including standards development and conformity assessment. These systems are the North American Metrology Cooperation (NORAMET) and the North American Calibration Cooperation (NACC). NACC concerns itself with the development of mutual confidence in national calibration laboratories through accreditation programs, while NORAMET coordinates the development of a joint system for uniform and accurate measurements. NORAMET objectives are: to develop closer collaboration in measurement and metrological services; to optimize the utilization of resources and services towards metrological needs; to encourage the sharing of major facilities; and to improve measurement services and to make them accessible to Member nations within agreed-upon limits.

In December 1994, the 34 Presidents of the Member States in the Organization of American States (OAS) participated in the "Summit of the Americas" held in Miami, Florida. The resulting "Declaration of Principle," seeks prosperity through economic integration and free trade by using metrology to eliminate technical trade barriers. Then in January 1995, NIST and the OAS organized a coordinating meeting for the representatives of the national metrology laboratories within the Americas which was held in Rio de Janeiro, Brazil. During this meeting, the representatives from 25 national laboratories agreed to revitalize the old Inter-American Metrology System (SIM) and to include all 34 of the OAS member nations. This meeting established SIM's structure, objectives, and action plans. SIM has planned a series of intercomparisons among the regions in various measurement disciplines that will link the regions together and lead to traceability. The first intercomparison, on mass, is underway.

NIST anticipates that actions by NAFTA and the proposed Free Trade Area for the Americas (FTTA) will reflect global market considerations, and that NAFTA and FTTA will work with other regional groups such as the European Union and the Asia Pacific group, as well as with the many other countries with whom trade and S&T cooperation have been established. Close cooperation and assistance of SIM and NORAMET will further strengthen the metrological capabilities and services in the Americas thereby enhancing efficiency in production and distribution of goods and services for the benefit of all globally.

Spurred by the NAFTA agreement, there has been a particularly strong effort to coordinate measurement technology with Mexico. Two years ago, Mexico established a new national measurement laboratory. A number of European nations donated sophisticated measurement equipment to this laboratory in hopes of opening broader trade opportunities. NIST has established extensive staff exchanges with Mexico. As a result, there is a good personal and professional working relationship between nearly all of the key technical leaders of the laboratory in Mexico and their NIST counterparts. An example of the benefits is a new cooperative approach to developing the standard reference materials needed to measure industrial emissions in both the United States and Mexico. Each nation will have access to the same measurement base. Total development cost is likely to be lower than if the work had been done independently.

Middle East

Still another example of using S&T to promote U.S. foreign policy objectives in a regional environment is the Middle East. Following the signing of the Camp David Peace Accords by the United States, Israel, and Egypt, the United States developed a program through the U.S. Agency for International Development to encourage regional S&T cooperation. This program, entitled the Middle East Regional Cooperative (MERC) Program, provided a means through which researchers from the different countries in the Middle East, who previously had no means of communications, let alone conducting joint research, could work together on research projects of regional interest. While the initial projects included researchers from only Egypt, Israel, and the United States, now many of them include scientists from other Middle Eastern countries. Despite cultural differences and the slow progress of the Middle East Peace Process, under the MERC Program researchers from countries in the region are currently working together on environmental, agricultural, and biomedical problems endemic to the region.

NIST has been involved in Middle Eastern regional activities for a number of years. In 1993, NIST hosted a regional workshop with the Egyptian National Institute of Standards (NIS) on "Science and Applications of the Measurement of Time and Frequency." Participants represented Israel, Egypt, and Saudi Arabia. In 1994, NIST, the U.S. Environmental Protection Agency, and the Egyptian Environmental Affairs Agency hosted a regional workshop entitled "Quality Management Systems for Environmental Monitoring and Measurements" which involved researchers from Egypt, Israel, Jordan, Morocco, Tunisia, Turkey, the EU, Japan, Russia, and the United States. In 1996, NIST sent two representatives to a regional meeting, held under the auspices of the Peace Process, to discuss standards development in the Middle East. NIST is planning another regional workshop, with funding from the U.S. Department of State, on standards, metrology, and conformity assessment scheduled for 1997.

Israel

While our regional efforts in the Middle East support the U.S. objective of encouraging the Peace Process, our bilateral relationships with Middle Eastern countries also support other strategic policy objectives. In the early 1970's the United States and Israel began a long and fruitful relationship supporting S&T-related activities. The Binational Science Foundation was established to support basic research cooperation. This Foundation has an endowment of $110 million consisting of equal contributions from the U.S. and Israeli Governments. The Foundation continues to fund joint projects with the interest earned on the endowment. A similar program, the Binational Agricultural Research and Development Foundation, supports joint agricultural cooperation and is endowed in a similar manner. A third foundation, the Binational Industrial Research and Development (BIRD) Foundation, was established to promote industrial R&D of mutual benefit to the United States and Israel. BIRD supports U.S.-Israel company partnerships dedicated to developing and commercializing non-defense-related innovative products or processes. The grants are paid directly to the participating companies. BIRD funds 50 percent of the companies' expenses in developing a product to the stage of commercial readiness. Financial support for BIRD is derived from two sources: interest earned on the $110 million endowment granted in equal parts by the United States and Israeli Governments, and repayment income from companies participating in successful BIRD-funded projects.

Egypt

Science and technology cooperation with Egypt is a high priority as it too supports the U.S. foreign policy objectives for the country and for the region. Not only does Egypt play a critical role in the Middle East Peace Process, Egypt may also serve as a gateway for U.S. industry into the Arab countries of the Middle East. Working with Egypt in the areas of standards, metrology, and conformity assessment could advance NIST efforts to assist U.S. industry overcome technical barriers to trade in the region. Under the auspices of the Science and Technology Joint Board of the Technology Subcommittee of the Gore-Mubarek Economic Initiative, the Egyptian Ministry of Scientific Research has proposed the establishment of a Memorandum of Understanding between the Egyptian National Institute of Standards (NIS) and NIST to promote cooperation in standards-related activities. As a result of the October 1995 S&T Joint Board meeting, the United States and Egypt identified cooperation in standards-related activities, biotechnology, and environmentally friendly manufacturing to be high priority areas for cooperation. In follow-up, with funding from the Joint Board, NIST and NIS hosted a workshop in Alexandria, Egypt, June 9-13, 1996 on standards, metrology and conformity assessment.

Saudia Arabia

The United States has a long history of cooperation with Saudi Arabia. For the past 4 years NIST has worked closely with the Saudi Arabian Standards Organization (SASO) in Riyadh. NIST maintains an experienced engineer in Rijadh working with SASO and with the Foreign Commercial Counselor in the U.S. Embassy. The NIST Standards Expert assists SASO with writing and revising documentary standards that have a strong influence on bilateral trade. That Expert sends to NIST those standards that do not agree with either international or U.S. standards where, with the help of staff from U.S. industrial associations, they are revised and then returned to SASO for further consideration. The NIST Standards Expert also assists with conformity assessment and certification to facilitate access of U.S. products to the Saudi market. The American business community in Saudi Arabia credits this arrangement with a substantial increase in U.S. exports to the Kingdom.

At the request of the U.S. business community, NIST is planning to expand this service to the remaining countries of the Gulf Cooperation Council (GCC). NIST recently signed an MOU with the GCC which documents the agreement to cooperate. Both sides are committed to cooperate on measurement, normative standards, and conformity assessment. This cooperation will include training and consultations, workshops and seminars, development of special codes such as automobile safety or building codes, and the exchange of information.

The NIST Standards Expert now working with SASO will manage this U.S. cooperation with the GCC countries. The chairman of the Standardization and Metrology Organization for the Gulf Cooperation Council is also chairman of the Saudi Arabian Standards Organization. NIST expects this expanded cooperation to benefit the U.S. business community and increase the effectiveness of NIST services in the region.

Eastern Europe and the Former Soviet Union

The United States has also used S&T cooperation as a means to prevent foreign scientific isolation and to encourage democratization by exposing the scientific and academic elite of communist and socialist countries to the western world. In the Former Soviet Union (FSU), for example, the United States developed an S&T program which brought scientists from the FSU to the United States to work in U.S. facilities, and sent U.S. scientists into FSU laboratories. This was done under the U.S.-USSR S&T Agreement. NIST developed the exchange program with the USSR Academy of Sciences, and recently signed an agreement to continue these exchanges with the Russian Academy of Sciences.

In Eastern Europe, similar programs were established to promote S&T cooperation, prevent scientific isolation, and encourage democratization. For example, with Hungary, Poland, and the former Czechoslovakia and Yugoslavia, jointly funded programs were initiated in the 1980's to support S&T cooperation in areas such as agriculture, engineering, environmental sciences, health and biomedical research, geology, basic research and energy-related research. With their foreign counterparts in these countries, NIST researchers have competed successfully for funding, and research projects were developed that continue today.

NIST scientists, Dr. Peter Pella and Dr. Richard Deslattes, collaborated with Dr. Marek Lankosz of the University of Mining and Metallurgy, Krakow, Poland. This project draws on the expertise of both countries to develop a unique in situ quantitative procedure for application to thin film analysis needed in the semiconductor industry. On other projects, NIST's Dr. William McLaughlin has successfully competed for funding twice. His work in chemical dosimetry explores advantageous techniques that are used in Eastern Europe but that are virtually unknown in the United States. This work has industrial and medical applications.

While the nature of the U.S. relationship with the FSU and Eastern Europe has changed dramatically over the years, the United States continues to support S&T cooperation. One important reason is to try to retain the scientific base in these countries. With the dissolution of the USSR, funding for S&T was severely diminished, and many Soviet researchers began looking elsewhere for support. Many of them began to emigrate to the "western world" where funding for S&T is easier to obtain. While this emigration certainly has the potential to enhance scientific efforts in many western countries, the brain drain from the FSU could severely hurt economic growth in the region, which could be devastating, not only regionally but globally. Therefore, it is within the strategic interest of the United States and, in fact, the world to assist in the development of a strong market economy in FSU countries. Many such efforts are underway in the United States to support the scientific base in the FSU, to encourage cooperation with scientists in the United States, and to develop a more stable scientific and technical infrastructure.

In FSU countries with nuclear capabilities, the United States has been very interested in working with FSU researchers to maintain nuclear safety standards. A major concern in the United States is that these researchers might be enticed to sell their expertise to the highest bidder in countries wishing to develop nuclear weapons. The Departments of Defense and Energy developed several programs to help support FSU scientists financially. One example is the recently established Civilian Research and Development Foundation (CRDF). The CRDF is a private, non-profit organization established by the U.S. Government to respond to the dramatic reduction in resources available for civilian scientific and engineering research in the successor states of the FSU. Legislation authorizing the CRDF was passed by the U.S. Congress in 1992. Initial funding for the CRDF derives from a $5 million contribution from the U.S. Department of Defense "Nunn- Lugar" program to promote demilitarization in the FSU and from a matching $5 million gift to the National Science Foundation by philanthropist George Soros. This unique public/private partnership supports joint research between public and private sector organizations in the United States and FSU countries. It funds civilian basic and applied research conducted in the FSU and promotes defense conversion and development of market economies in the region. NIST has been involved in this program from its inception, helped draft proposal criteria, and helped develop a mechanism for reviewing industry proposals.

In September 1996, the CRDF announced the results of its first cooperative research grants competition and acknowledged financial commitments by countries of the FSU to joint funding. The awards totaled $10.1 million in 238 cooperative research grants to teams of scientists in the United States and FSU. Two of these projects involve NIST scientists. Funding for a second round of competition for CRDF grants derives from a $1 million contribution from the National Institutes of Health, a $2 million contribution from the National Science Foundation, and a matching $3 million contribution from the Department of Defense funds in the "Nunn-Lugar" program.

Central Asia

In the Central Asian Republics, the United States continues to support S&T cooperation to help gain U.S. access to the various natural resources in the region and to provide commercial opportunities for U.S. industry, particularly the gas and oil industry. Kazakstan is the largest of the Central Asian Republics. Since the breakup of the USSR, the government of Kazakstan has initiated a number of reforms, and is committed to the development of a free market economy and full integration into the world economy. From the U.S. perspective, Kazakstan represents a substantial market for oil and gas equipment and services and other infrastructure-related technologies. U.S. market access would be facilitated by harmonization of standards and certification procedures. NIST recently signed an MOU with Kazakstan's Committee for Standardization, Metrology and Certification to facilitate the harmonization of Kazak standards, metrology and technical regulations with internationally accepted practices.

NIST's Role in Regulatory Activities

NIST's involvement in international activities also supports objectives of other U.S. government agencies, including regulatory agencies which use measurements to assure the health and safety of U.S. citizens abroad. Regulatory agencies maintain this assurance through regulations, audits, and laboratory accreditation, which may require compliance with measurement standards, including those derived at NIST. This is the case with the Federal Aviation Administration which regulates and accredits aircraft repair stations, both foreign and domestic. These repair stations maintain the airworthiness of U.S. flag carriers and have to comply with the Federal Aviation Regulations (FAR). One of these FARs identifies traceability to NIST directly. The particular FAR that has required NIST to become internationally active is FAR 145.47(b) which states ".... that the station shall ensure that all inspection and test equipment is tested at regular intervals to ensure correct calibration to a standard derived from NBS/NIST or to a standard provided by the manufacturer. In the case of foreign equipment, the standard of the country of manufacture may be used if approved by the Administrator."

This provision requires that all foreign repair stations have their calibrations traceable to NIST. The problems that those repair stations have in complying with this FAR are: the expense in time and money of sending their equipment to NIST for calibration or to "traceable laboratories" that are not in the country; the by-passing of their countries' national metrology laboratory if no mutual equivalency agreement exists between that laboratory and NIST; and the risk of loss or damage to their equipment. In addition, this provision impacts countries with national airlines that have planes on lease from the United States, since these planes have to comply with the same regulations as the planes of U.S. flag carriers. NIST is placed in the position of resolving the issue with the repair station, the foreign national metrology laboratory, and the FAA. NIST works with the respective national metrology laboratories or with the regional group to which those national laboratories belong on intercomparison measurements through which the laboratories provide the necessary traceability via their calibration services. Additionally, NIST through its National Voluntary Laboratory Accreditation Program could develop a mutual recognition agreement with the accrediting body in the respective country. NIST also has to work with the FAA to ensure that the actions being taken are recognized by the FAA and will be reflected in their future regulations.

Conclusion

S&T cooperation has made a significant contribution to U.S. foreign policy objectives. For example, in the Middle East, S&T cooperation has been a key component of our efforts to promote peace. Since 1979, with support from the United States, Middle Eastern researchers have been working together to address important S&T issues which affect the entire region. In addition, S&T is a key component of the on-going Middle East Peace Process, especially research and development that transcends national boundaries such as improving trade, combating diseases, and reducing environmental degradation. Cooperation with the former Soviet Union and Eastern Block nations during the Cold War not only provided U.S. researchers access to state of the art research in those countries, it also supported the U.S. effort to promote democratization by exposing those researchers to the western world. In Mexico, cooperation has played a significant role in promoting economic growth by assisting the Mexicans in establishing their own national metrology laboratory which serves as one of the lead laboratories in the Interamerican System of Metrology.

As can be seen through these few examples, NIST plays and will continue to play an important role in S&T cooperation in support of a variety of U.S. foreign policy objectives. This role in some instances is a "carrot" or is a leveraging mechanism. Where NIST plays a particularly strong role is when the S&T agreement is intended to be a stepping stone for economic development in the countries on the receiving end. S&T cooperation also is a non-threatening form of interaction in which all countries want to participate. Many countries are especially interested in cooperation with NIST because they see such cooperation as particularly beneficial to their own economy.

Appendix 1

"The National Export Strategy Toward the Next American Century: A U.S. Strategic Response to Foreign Competitive Practices"

Fourth Annual Report by the U.S. Trade Policy Coordinating Committee to the United States Congress, October 1996: Recommendations from the Standards Chapter entitled, "Strategic Standards Commercial Policy"

"Standards and conformity assessment requirements imposed by other national and regional authorities have become a critical factor in determining the competitiveness of American firms and workers. Our trading partners are increasingly using product standards as a tool to gain competitive advantage for their exports to rapidly developing countries.

This can occur through a variety of approaches, through foreign assistance programs which target the development of key elements of a country's technical infrastructure (such as the case with Japan and Australia in the Pacific Rim, or European programs in Central and South America, Eastern and Central Europe and Asia) or through the negotiation of trade agreements covering the harmonization of standards (EU agreements throughout Central Europe, and ongoing EU discussions with Russia, Ukraine, and some Latin American countries). Standards practices can be an obstacle to entire markets for U.S. companies---particularly small companies---without the resources to counter these efforts.

We must implement both near term efforts---to gain increased foreign recognition of standards in broad use by U.S. industries---as well as a long-term program focused on harmonization at the international level. Our goal is a single test of a given product against a given standard, accepted world-wide, and to help U.S. industry adjust when these new standards differ from those currently used in the United States." (From Executive Summary.)

Recommendations

- **"Emphasize technical assistance programs as a basis for long term internationalization of standards and harmonization efforts by:**

  Working with U.S. industry and standards developers to identify and implement proactive strategies for participating in the development of international standards that support U.S. needs.

  Encouraging U.S. industry, standards developers, and government agencies to review WTO notifications and proactively comment on proposed foreign market regulations with a view to achieving greater harmonization reflective of U.S. technologies and practices.

Examining the feasibility of posting U.S. standards experts at additional key embassies in Asia, Eastern Europe, Russia and Latin America and support them with comprehensive technical assistance from the U.S. public and private sectors.

Continuing focused programs dedicated to standards-related training and outreach to overcome our competitors' advantage in developing global markets. Expand existing programs, such as the SABIT Standards Program, to reach markets where the trade potential is greatest and where adoption of standards compatible with ours will best leverage future U.S. exports, such as Asia, Eastern Europe, South and Central America.

Working with U.S. standards developers to provide up-to-date copies of U.S. standards in target markets.

- **Strengthen Competitive Commercial Policy with Multilateral and Bilateral Standards Initiatives:**

Continue to seek full and effective implementation of the WTO TBT Agreement. Through the Trade Policy Staff Subcommittee (TPSC), and in consultation with appropriate advisory and congressional committees, the United States will consider ways to strengthen the discipline of the Technical Barriers to Trade (TBT) Agreement to resolve standards-related barriers to trade and will advance its proposals in preparation for the TBT Committee's first triennial review of the operation of the Agreement.

Negotiate MRAs to achieve broad acceptance of demonstrably valid test data and product approvals. Our first priority should be conclusion of a U.S.-EU MRA. The next step is to set clear priorities for target markets for additional MRAs, and to begin preliminary discussions. We will consult broadly within the government and with private sector representatives to determine these priorities.

Work toward full implementation of NAFTA's provisions on conformity assessment, and using regional fora, including FTAA and APEC, to advance discussions on how to improve market access and resolve conformity assessment issues.

- **Increase the role and effectiveness of the U.S. private sector, including better use of advisory committees to achieve market access in standards related matters.**

We will work cooperatively with the Industry Functional Advisory Committee, interested Industry Sector Advisory Committees, Business Development Committees (BDCs) in emerging markets and the USEU Transatlantic Business Dialogue (TABD) to develop appropriate goals for our commercial strategy and leverage private sector involvement in bilateral discussions of standards-related issues.

Ensure that future private/government trade groups focus on key technical infrastructure issues and sectorial priorities, and establish focused work programs; and

Provide a link between BDCs and government negotiators to encourage government implementation and adoption of BDC initiatives in standards-related areas.

- **Strengthen U.S. technical infrastructure implementation:**

  In cooperation with the private sector, the National Institute of Standards and Technology will work to implement---as soon as possible---a laboratory accreditation infrastructure for recognizing all competent U.S. laboratories and accreditors, leading toward the objective of a single test of a given product, conducted by a suitably accredited laboratory, with results acceptable to all users, both domestic and foreign. This will require development of a constitution and procedures, commitment and support from other Federal and State agencies, and linkage with international bodies.

  Extending the concept of a unified laboratory accreditation system to encompass other forms of conformity assessment, including product certification and management system audits under ISO 9000 and ISO 14000.

  Building regional networks for fundamental physical measurements, such as the North American Calibration (NACC) and the Metrology Cooperation (NORAMET). These efforts should be extended to other regional metrology organizations as well.

- **Develop initiatives targeted to facilitate small business access to international standards activities by:**

  Addressing the burdens of differing certification systems in the international marketplace by assessing the potential for mutual recognition agreements, equivalency agreements, and reliance on manufacturer's certification to technical requirements. These kinds of bilateral or regional agreements should greatly reduce the cost and delays of compliance with standards requirements.

  Ensuring that U.S. technical and commercial agencies as well as standards developers make available accurate international standards information in a comprehensive and timely way to the small business community through trade associations, technical societies and government outreach programs, including an Internet site.

  Placing particular emphasis on addressing small business market access concerns about technical issues such as standards, testing and certification, and assisting small business to influence the developers of foreign market requirements to maintain and expand open markets."

Acronyms
in
NIST International Activities Report

Acronym	Definition
A2LA	American Association for Laboratory Accreditation
ACIL	Formerly American Council of Independent Laboratories
AID	Agency for International Development
ANAPRQS	American National Accreditation Program for Registrars of Quality Systems
ANS	American National Standards
ANSI	American National Standards Institute
ANSI-RAB	American National Standards Institute - Registrar Accreditation Board
APEC	Asia Pacific Economic Cooperation
API	American Petroleum Institute
APLAC	Asia Pacific Laboratory Accreditation Cooperation
APMP	Asia Pacific Metrology Program
ASHRAE	American Society of Heating, Refrigerating, & Air Conditioning Engineers
ASME	American Society for Mechanical Engineering
ASTM	Formerly the American Society for Testing and Materials

Acronym	Definition
BEMs	Big Emerging Markets
BIPM	International Bureau of Weights and Measures (BIPM operates under the CIPM or the Comité International des Poids et Mesures which itself operates under the CGPM or the Conférence Géńerale des Poids et Mesures.)
BIRD	Binational Industrial Research and Development program (U.S.-Israel)
BOCA	Building Officials and Code Administrators International, Inc.
CAR	Central Asian Republics
CCE	Consultative Committee for Electricity (BIPM)
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CGPM	See BIPM
CIB	International Council for Building Research, Studies and Documentation
CIE	International Commission on Illumination
CIPM	See BIPM
CIS	Confederation/Commonwealth of Independent States (former Soviet Union)
Codex Alimentarius Commission	International government-to-government body for food standards and codes (FAO/WHO Food Standards Program)

Acronym	**Definition**
COOMET	Eastern European Metrology Cooperation
COPANT	Pan American Standards Commission
CRDF	Civilian Research and Development Fund (U.S. funds for former Soviet Union)
CSIR	Formerly called the Council of Scientific and Industrial Research (S. Africa)
DIN	The German standards developing body
EAL	European Cooperation for Accreditation of Laboratories
EC	European Community
ETSI	European Telecommunications Standards Institute
EU	European Union
EU-MRA	European Union - Mutual Recognition Agreement
EUROMET	European Metrology Program
FACA	Federal Advisory Committee Act (U.S.)
FSU	Former Soviet Union
FTAA	Free Trade Area of the Americas (planned)
GATT	General Agreement on Tariffs and Trade
GCC	Gulf Cooperation Council (Middle East)
GDP	Gross Domestic Product
GIQLP	Government Industry Quality Liaison Panel (U.S.)

Acronym	Definition
GOSSTANDART	Russia's standards organization---also metrology and certification
ICBO	International Conference of Building Officials
ICSP	Interagency Council on Standards Policy (U.S.)
IEC	International Electrotechnical Commission
IECEE	IEC's System for Conformity Testing to Standards for Safety of Electrical Equipment
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
ILAC	International Laboratory Accreditation Conference
IMGC	Istituto di Metrologia "G. Colonnetti" (Italy)
INMETRO	National Metrology Laboratory (Brazil)
IPC	Interoperability Policy Council (of North America)
ISDN	Integrated Services Digital Network Chapter
ISO	International Organization for Standardization
ISO 9000	Series of standards for quality management systems produced by the ISO
ISO 14000	Series of standards for environmental management systems produced by ISO
ISO-CASCO	ISO's Conformity Assessment Committee
ISO-DEVCO	ISO's Developing Nations Committee
ISO-INFCO	ISO's Information Committee

Acronym	Definition
ISONET	ISO's Information Network
ISO-REMCO	ISO's Reference Materials Committee
ITI Council	Information Technology Industry Council
ITU	International Telecommunications Union
IUPAC	International Union of Pure & Applied Chemistry
JTC-1	ISO/IEC Joint Technical Committee on Information Technology
LAWG	Laboratory Accreditation Working Group
MERC	Middle East Regional Cooperation program
MOU	Memorandum of Understanding
MPA NRW	Materialprufungfant Nordrhein-Westfalen (Germany)
MRA	Mutual Recognition Agreement
NABL	National Accreditation Board for Testing and Calibration Laboratories (India)
NACC	North American Calibration Cooperation
NACLA	National Council on Laboratory Accreditation (proposed)
NAFTA	North American Free Trade Agreement
NCSCI	National Center for Standards and Certification Information
NCSL	National Conference of Standards Laboratories
NCSL	National Council of State Legislatures
NCWM	National Conference on Weights and Measures

Acronym	Definition
NELAC	National Environmental Laboratory Accreditation Conference
NFPA	National Fire Protection Association
NIS	National Institute of Standards (Egypt)
NIS	Newly Independent States (former Soviet Union)
NMI	National Measurement Institution (NIST in the U.S.)
NORAMET	North American Metrology Cooperation
NRLM	National Research Laboratory of Metrology (Japan)
NSSN	National Standards Systems Network (NIST/ANSI)
NTRLs	Nationally Recognized Testing Laboratories
NVCASE	National Voluntary Conformity Assessment Systems Evaluation Program (NIST)
NVLAP	National Voluntary Laboratory Accreditation Program (NIST)
OAS	Organization of American States
OECD	Organization for Economic Cooperation and Development
OIML	International Organization of Legal Metrology
OSS	Office of Standards Services (NIST)
PASC	Pacific Area Standards Congress
QCI	Quality Council of India
RILEM	International Union of Testing & Research Laboratories for Materials and Structures
SABIT	Special American Business Internship Training

Acronym	Definition
SAE	Society of Automotive Engineers
SASO	Saudi Arabian Standards Organization
SASO-ICCP	Saudi Arabian Standards Organization - International Conformity Certification Program
SBCCI	Southern Building Code Congress International Inc.
SDOs	Standards Developing Organizations
SDS	Service Development Surcharge
SI	International Systems of Units
SIM	Inter-American System of Metrology
SIT	Standards in Trade (a NIST program)
SMO-GCC	Standards and Metrology Organization for the Gulf Cooperation Council (Middle East)
SRM	Standard Reference Material
SRR	Social Rate of Return
STRS	Science & Technology Research & Services (NIST $)
TAG	Technical Advisory Group
TBT	Technical Barriers to Trade
TBT Agreement	Technical Barriers to Trade Agreement (GATT/WTO)
TC	Technical Committee (eg. of ISO)
UL	Underwriters Laboratories
UNECE	United Nations Economic Commission for Europe
USIF	U.S.-India Fund

Acronym	**Definition**
USNC	U.S. National Committee (to the IEC)
USTR	U.S. Trade Representative
VAMAS	Versailles Project on Advanced Materials and Standards
VIM	the International Vocabulary of Basic and General Terms In Metrology (the "VIM")
WCF	Working Capital Fund
WTO	World Trade Organization

NIST Technical Publications

Periodical

Journal of Research of the National Institute of Standards and Technology—Reports NIST research and development in those disciplines of the physical and engineering sciences in which the Institute is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Institute's technical and scientific programs. Issued six times a year.

Nonperiodicals

Monographs—Major contributions to the technical literature on various subjects related to the Institute's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NIST, NIST annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NIST under the authority of the National Standard Data Act (Public Law 90-396). NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published bimonthly for NIST by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

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NIST Interagency Reports (NISTIR)—A special series of interim or final reports on work performed by NIST for outside sponsors (both government and nongovernment). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche form.

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