Technical standardization

Standardization in the modern world refers to a form of voluntary rule setting that prescribes appropriate characteristics for artifacts or organizations so as to facilitate their reliable, orderly use and integration in wider applications, including commerce.

Standardization has accompanied the development of human culture from prehistoric times. Language depends on standardized relationships between human sounds and meanings; writing depends on similar connections between signs and either sounds or ideas; commerce and trade have always depended on standard weights and measures; and monetary economies and international trade have always required currencies calibrated to a standard measure of value, such as gold (hence 'the gold standard'). As societies have become more sophisticated, their reliance on standards has grown. The ancient Mesopotamians standardized the size of building modules (bricks and tiles), while the Romans economized on materials and labour in building their vast road network by standardizing axle lengths on their chariots to 1435 mm (the same gauge that most railway networks use today).

Transnational beginnings in the electrical world

Today's organized practice of standardization began with three 19th-century technical advances – mechanized production of artifacts with interchangeable parts (such as small arms, clocks, sewing machines and bicycles); electrical power generation, with its applications in lighting, motors and public transport; and the related development of telegraphy and telephony. In the latter half of the 19th century, mass production of standardized products with interchangeable parts made standardization a central production principle. The development of electrical supply and its applications also called for standardized measures and dimensions, starting with units of electrical current and resistance.

At first each industrialized country established its own units. But the new electrical supply industry, telegraphy, telephony and other forms of electrical transmission, and the burgeoning trade in dynamos, cables, transformers, motors and other equipment, required harmonization across national borders.

In 1865, 20 European states founded the International Telegraph Union (today's International Telecommunication Union), now the world's oldest international organization. The Union standardized equipment and protocols so as to facilitate telegraphy across national borders. It soon came to do so for telephony and radiotelephony as well, and later took charge of the radio spectrum when broadcasting began in the 1920s. It now plays a vital role in information and communication technology.

The 1875 Metric Treaty pioneered the development of shared, precise units of physical measurement (also known as 'physical standards'), which underpin all other standards except today's management standards. Six years later the first International Electrical Congress in Paris established common measures of electrical current, and thus a milestone in standardization. Though it was formally an international conference, scientists and industrialists drove the proceedings without reference to *raison d'état.* It set the pattern for transnational technical standardization to this day: states formally attend at the birth of international bodies, but deliberations and action proceed in their absence.

Follow-up conferences occurred every five years, until the 1904 conference decided to establish a permanent body. The founding congress of the International Electrotechnical Commission (IEC) was duly held in London in 1906. At its founding congress, the Verband Deutsche Elektrotechniker argued strongly for the exclusion of 'government' influence and met little opposition.

The IEC set a precedent, which all significant regional, global and transnational standards bodies would follow, for developing standards in international non-government organizations. Delegates referred to themselves as representing a 'movement', and even a 'brotherhood', one intended to prove a model for peaceful coexistence. Standardizers nationally and transnationally would preserve this sense of themselves well into the post-World War 2 period. True to this idea, the IEC executive was called 'the Committee of Action' (nowadays the Standardization Management Board), and an expert 'advisory committee' (later 'technical committee') came to take charge of each of the major areas of concern to the early IEC – development of a common vocabulary, common symbols, and ratings for electrical apparatus. The early emphasis

on developing common units of measurement and technical terms in the IEC makes it a clear case of an epistemic community. It constantly refined the system of measurement of electrical current, and (in the interwar period) of radio frequencies. In 1938 it published its *International electrotechnical vocabulary*, with over 2,000 terms in English, French, German, Italian, Spanish and Esperanto. The IEC remains one of the three main transnational standardizing bodies to this day.

Along with the early national standards bodies, the IEC established today's modus operandi in legitimate standards organizations, one based on a plurality of interests represented. Committees consisted of ostensible 'experts' drawn from the different interest groups affected by the project in hand. Thus they were not 'disinterested' individuals, and only in recent times has the issue of wider and proportionate representation of all 'stakeholders' been addressed. Even so, standardizers were expected to deliberate 'transparently' and arrive at consensual decisions. In particular, this ethos informed the technical committees that developed standards and associated handbooks and guides. Each technical committee had at its disposal a secretariat that a national standards body offered free of charge. This approach underpins transnational standards work to the present time.

The first organization to commit itself to transnational standardization outside 'the electrical world' was the Swiss standards body, Verein Schweizerischer Maschinenhersteller Normalienbureau. From 1923 it invited national standard bodies from abroad to join it and cooperate in producing joint standards, mainly for mechanical engineering. Three years later the International Standards Association (ISA) was formed and took over this work. The ISA represented an early attempt to build an international standards body with a much more general mission than the IEC's: to reduce technical barriers to trade in the form of idiosyncratic, nation-specific standards. It adopted the IEC's organizational model, one centred on technical committees on which the interests of the various countries and functional groups were supposedly balanced. Once again, however, the actual composition of committees favoured those interests with sufficient resources and determination to field 'volunteers'.

The ISA had a small secretariat in Basle, and concentrated on issues relevant to Continental European countries, especially in mechanical engineering. It worked exclusively in metrics, which reduced its appeal to non-metric countries. Soon it faced the 1930s Depression, which encouraged protectionist forces with no sympathy for ISA's agenda. Though its achievements were modest, it had enrolled 21 national standards bodies by the outbreak of war in 1939, which forced it into mothballs.

The League of Nations, founded in 1920, fed off the same spirit of internationalism and peaceful coexistence in the 1920s, and undertook important standardization activities of its own, not least in the area of healthcare (for instance, in standardizing the classification of blood groups and measures for vitamin intakes). Closely aligned to it, the International Labour Organization (ILO) laid the groundwork for establishing international labour standards.

National standards bodies

As noted, standardization emerged in the 19th century as a production concept in the mass production of artifacts with interchangeable parts. Mass production of standardized goods drastically reduced unit costs and brought other benefits to consumers. Starting with the American Civil War, mass production also became a vital part of military capacity. But the gains from standardization went well beyond the sphere of production. Installation and design standards promised greater safety in buildings, their wiring and plumbing. Network standards allowed trains to move across state borders, and telegraphy and telephony to span the world. Eventually they would underpin today's interoperability of remote computers. Quality, safety and sheer doability also became part of the standardizer's *raison d'être*.

In the leading industrial countries, standardization arose spontaneously, in rational solutions to immediate production issues. In late-industrialising countries, such as the British dominions, standardization became a vital mechanism of technology transfer, such that standardizers took a leading role in economic development. In both cases, standardization was often contested, as it challenged those with a vested interest in parochialism, older technologies, or monopolies.

Resistance to standardization helped mould standardizers' self-image as a transnational

'movement' – one that, especially in the 1920s, would work alongside other movements around 'rationalization' in general, and such specific causes as 'simplified practice'. The latter promoted standardization by reducing superfluous variety in manufactured goods on the market. All these movements united under the slogan of 'rational progress', and 'propaganda' for it constituted a normal, explicit item on the early national standard bodies' agenda. Standardizers now came from much more varied disciplinary and occupational backgrounds than the electrotechnicians of the IEC, but engineers of varying specializations took the lead. As a profession, engineers gained enormous prestige from mass production; and as a professional corps, they evangelized for the socioeconomic benefits of standardization.

The earliest important national standards bodies appeared before or during World War 1 – in Britain in 1901, and in Germany and the USA in 1917. The 1920s saw their emergence in most advanced economies, even if the latter were not yet industrialized, as in the Australasian cases. Some formed spontaneously, while others were initiated by governments seeking to forge the link between science and industry as part of national development.

At first almost all national standards bodies represented an amalgam of engineers and industrialists, who came together in non-government voluntary associations, and were conscious of belonging to civil society rather than the state. They followed the British and IEC precedents in espousing democratic procedures and a plurality of interests on technical committees, even if the latter was not always achieved in practice. Above all, national standards bodies promoted the principle that the adoption of standards was voluntary. As civic organizations they have brought together large numbers of unpaid individuals from many walks of life on their technical committees – individuals who thus gain the opportunity to network, and to hone their technical and civic skills simultaneously. For instance, in 2006 a middling national standards body such as the Australian one had 8,193 experts on its 1,576 technical committees and subcommittees.

A number of factors complicated relations with governments. In many cases national standards bodies depended on government subsidies. And in spite of the voluntary principle, governments became major users of standards in regulation, starting with such basic functions as electrical wiring rules and safety requirements in building codes, which thereby became mandatory. In the booming 1920s, governments and industries also realized the trade benefits of standardization, and so worked towards a system of national standards, with conformance trademarks branded onto products. As the developers of national standards, the national standards bodies thus sought exclusive governmental recognition of their products.

In this way the latter gained prestige over proprietary and industry standards, which lack legitimacy since they are produced by individual enterprises and trade associations respectively, without the 'transparent', participatory procedures of the national standards bodies' technical committees. Governments have also had to take responsibility for national measurement systems. National standards bodies thus had to cooperate with national measurement laboratories and testing facilities, which ensure that all measuring instruments used in the wider economy are accurately calibrated in order to secure recognition in export markets. Today this private–public network, or 'national technical infrastructure', extends into forms of transnational cooperation.

In World War 2, national standards bodies became vital nodal points of the home front in wartime. Technological innovation, diffusion and transfers accelerated, in turn demanding vast numbers of war emergency standards. National standards bodies then worked intimately with many arms of their own governments and – in the case of belligerent countries – with allied national standards bodies. But in spite of all their links to government, and their later consorting with the state-based standards institutes of developing countries in the many transnational standards forums, the older national standards bodies have always remained embedded in civil society, and thus maintain an arm's-length relationship to government.

The national standards bodies' agenda has gradually expanded from product, design, installation and network standards. The 1930s saw growing interest in quality control standards, which would lead to the widespread use of such process standards in munitions industries in World War 2, and much more generally afterwards, as well as certification

and trademarking based on standards. Governments extended their use of national standards in their own purchasing routines and in detailed regulation.

The national standards bodies' expanded agenda led them to drop words like 'engineering standards association' from their names. In the 1970s they responded to a huge increase in the demand for consumer and safety standards. A decade later they began another expansion into quality management (or 'administrative') standards which replaced the older forms of quality control standards, and which have opened up a whole new field of management standards (including ones covering environmental issues, knowledge, risk, record keeping, regulatory compliance and 'social responsibility'). The arrival of information technology (IT), and technological change in telecommunications, have massively increased the field of network standards, especially to achieve interoperability in computer-based technologies, such as electronic funds transfers.

Trade, war and internationalization

As we shall see, regional, global and transnational standards forums and organizations now play a salient role in global economic regulation under the catchcry of harmonization of national standards. Development of trade and standardization arrangements in the British Empire between the wars prefigured postwar trends. The imperial government was pursuing a policy of replacing centralized control from London with a decentralized, 'federated' empire (soon to be redubbed a 'commonwealth of nations') consisting of several sovereign dominions, as well as a residue of crown colonies.

The empire, which at the time comprised a quarter of the world's population, would continue to function as a trading bloc. Harmonizing national standards was recognized as the key to the free flow of goods throughout the 'empire-preference' area. Standardizers met in separate caucuses during the five-yearly intergovernmental imperial conferences, but personal visits by leading standardizers were more frequent. The British Engineering Standards Association (from 1931 the British Standards Institution, BSI) encouraged the development of national standards bodies in the dominions, and negotiated with them flexible licensing arrangements whereby they published and sold common standards where appropriate, and mutual rights to conformance testing where they were not. Imperial national standards bodies marketed each other's standards, and maintained reference libraries with holdings of imperial and foreign standards.

In the 1930s, the BSI sought to harmonize trademarking throughout the empire: each dominion was to legislate to protect standards-compliance trademarks, and each national standards body should register its standards-conformance mark, which should then gain recognition throughout the empire. This idea sparked an early interest in process standards, which were already being used in certain firms in the US as a means to ensure that mass-produced goods conformed to the appropriate standards before they qualified for a mark. This system became a prototype for much later regional and global trading arrangements, including in today's European Union.

War brought a drastic shift in standardizers' focus from trade to technological innovation and diffusion at home, and technology transfers between allied countries. The experience of dealing with these contingencies would have a formative influence on postwar transnational standards arrangements. Even neutral industrial countries like Sweden had to switch to import-replacement manufactures, and for the first time produce goods that it had previously imported, or that had no peacetime application, such as air-raid shelters. Belligerent countries faced the same challenge, but also had to optimize armaments manufacture on the basis of rapid technology transfers from their allies. All these endeavours demanded publication of the requisite standards as a prelude to production and installation, and national standards bodies were stretched to their limits producing new, mutually compatible standards at short notice.

These issues prompted a long joint wartime project between national standards bodies that continued into the postwar period – 'ABC work' (America-Britain-Canada), that the respective bodies undertook so as to harmonize engineering-drawing and screw-thread standards, among many others. To facilitate this cooperation, Allied governments directed their national standard bodies to form a new organization, the United Nations Standards Coordination Committee

(UNSCC), whose executive met for the first time in London, in June 1944. Its immediate function was to support the war effort by eradicating obstacles to technology transfers. But even at the time its spokespeople pointed to its potential to reduce technical barriers to postwar trade. For that, the UNSCC would have to develop into a far more inclusive body, and a more effective one than the ISA had been.

The first general meeting of UNSCC took place in New York in October 1945. All Allied national standards bodies attended, as well as those of Mexico and Brazil. Plans were laid for a new international body, and negotiations started with remnants of the ISA. On 14 October 1946 (which subsequently became World Standards Day), a conference – jointly hosted by UNSCC and ISA – took place in London. Delegates from 25 countries attended and formally launched the International Organization for Standardization (ISO).

In spite of Americans' taking the most visible leadership positions, the founding of ISO represented a shift away from the dominance of the English-speaking countries. The new organization based itself in Geneva; two years later the reactivated IEC – now affiliated to ISO but retaining its autonomous field of operations – moved its headquarters from London to Geneva as well. Eventually the two organizations would occupy the same building there, share some personnel and launch a number of joint technical committees. ISO's membership at the turn of the 21st century consists of 159 national standards bodies, including some 'corresponding' and 'subscribing' associate members. Only one organization from each country is admitted to membership.

The founding of ISO took its place in a flurry of diplomatic activity whereby the Allies sought to promote postwar reconstruction on the basis of trade liberalization and collective security. Alongside the UN, they founded the Bretton Woods international monetary regime, the World Bank, the International Monetary Fund, and the General Agreement on Tariff and Trade (much later replaced by the World Trade Organization). ISO was thus born to help clear away technical barriers to growing trade flows; it was to make 'recommendations' that its constituents could write into their national standards, which would thereby be 'coordinated' for trade purposes.

Transnationalizing standards development

The old rhetoric of rational progress revived in the postwar period, and with it many of the prewar transnational networks. Some of the initial ISO technical committees were in fact resuscitated ISA ones – a relationship that mirrored the UN's own takeover of a number of the League of Nations' departments, including those that had engaged in standardization during the interwar period, such as its healthcare one. But ISO soon spawned many more technical committees; after ten years it had 80 active committees, and by 2006 it had 229, many of them with attendant subcommittees and working groups. One of the formative influences on its development was Olle Sturén who eventually served a record term (1968–86) as ISO's general secretary. He raised ISO's stature above that of a 'European club', a stigma it inherited from ISA, by enrolling many national standards bodies from developing countries as active members. Today the vast majority of ISO's members represent these countries.

In 1970, as part of a watershed year that included the founding of the *ISO Bulletin* and the proclamation of World Standards Day, Sturén initiated a whole new category of international standards to eventually supersede the lowlier ISO 'recommendations'. In this way ISO claimed a whole new primacy for its products. Instead of being a clearinghouse for incompatibilities between national standards, international standards would ideally pre-empt the content of national standards: the latter would simply be rebadged international standards.

It was a bold move, given the degree of nationalist sentiment (not least in the US) around standards development, and the fact that ISO's technical committees, dependent as they were on international meetings, tended to work more slowly than those of its national affiliates. In the 1990s, ISO struggled to reduce the average development time for a new standard from seven to five years. Those national standards bodies that embraced the new concept often found themselves nonetheless forced to develop provisional national standards in response to the rapid pace of technological change. In both cases standards development was a time-consuming deliberative process, such that standardizers have always faced criticism from users for not having published a suddenly urgent standard

'yesterday'. Where a national standards body published a reasonable standard in such circumstances, the relevant ISO technical committee often used it as a 'source document', and even as the first draft of an international standard, so reducing its own lead time.

As ISO's level of ambition rose, it had to face the underrepresentation of more distant and less developed countries. As John Boli has argued, INGOs such as ISO base their legitimacy on the principle of rational voluntarism, since they are neither the organs of coercive states nor able to exercise financial *force majeure*. Their representativeness and transparent, deliberative processes underpin the authority of their products. ISO has thus had to devise mechanisms whereby remote constituents could give written feedback on draft standards, and to see that their feedback was taken seriously, if they were to support the resulting standards, guides and handbooks.

Intensifying economic internationalization, however, bolstered Sturén's brainchild in at least three ways. Firstly, the General Conference on Weights and Measures, which administers the international metric system, had adopted a set of more exact units of measurement (*Système international d'unités*, or 'SI units') in 1960. This move precipitated a wave of national metrications in the 1970s in the previously non-metric world; today only Liberia, Burma and the US remain outside the metric system. National standards bodies in metricating countries could then recast all their dimensional standards in metrics, which boosted trade and eased cross-cultural contacts.

Secondly, the Tokyo round of GATT meetings (1973–79) worked towards its Standards Code, which would oblige signatories to remove technical barriers to trade from their standards regimes; adopting international standards would ensure compliance with it (and with its successor, WTO's Standards Code). In 1980 GATT officially adopted the Code. In 2006, 118 national standards bodies and three EU ones had acceded to the WTO Code. Today WTO enjoys a strategic partnership with the ISO, IEC and ITU, and ISO is represented on WTO's Committee on Technical Barriers to Trade.

Thirdly, firms began to do much more business with remote partners, especially with the rise of global information technologies, and could no longer rely on local business cultures to enquire whether potential partners produced quality products or services, and could be relied on to do so over time. The apparent answer to this problem came in the form of management standards, in the first instance generic quality management standards. In 1979 ISO set up its own technical committee (ISO TC 176) to develop quality management standards, and in 1987 it published its ISO 9000 series. The rate at which these standards were adopted as national standards, and sold to firms around the world, dispelled any lingering doubts about the viability of international standards. Firms and other organizations could gain certificates of compliance against ISO 9000, which became their legitimation cards on the global market. The certificate's appearance on an organization's website supposedly settled most doubts about its management, performance, reliability and probity.

In this way a new worldwide industry was born around consultant-driven implementation of ISO 9000, certification to these standards, and the accreditation of certifying bodies. Many national standards bodies have participated in this industry through for-profit subsidiaries that provide consultancy and certification services, and their participation has accorded the formally not-for-profit national standards bodies an unprecedented financial solidity. In 1994 and 2000, ISO published updated versions of the ISO 9000 series. It has also published other management standards covering such aspects of corporate life as risk management, complaints handling and regulatory compliance, as well as another major series of standards for environmental management, ISO 14000. In short, quality management standards were the major icebreakers for international standards as a whole.

In 2004, ISO braved initial controversy and committed itself to developing a standard (ISO 26000) for social responsibility in organizational life, to be published in 2008. This project raises its level of ambition still further, both in its subject matter and in the time frame it has set itself: when it subtracts time for public comment, it has only three years in which to develop this thorny concept.

In a development largely compatible with the ISO/IEC transnational standards infrastructure, regional standards bodies have grown up, starting with the European standards body, CEN (Comité Européen de Normalisation) in 1959. CEN and its electrotechnical counterpart, CENELEC

(founded in 1973), led the struggle towards harmonized European standards in order to achieve a single, integrated European economy by 1992, in what is now the EU. Those aware of similar endeavours in the interwar British empire might have watched this development with a sense of *déjà vu*. Comparable regional standards bodies seeking to facilitate trade have been set up in the Americas (COPANT in 1961), Arab countries (AOSM in 1967), the Pacific Rim (PASC in 1973) and Africa (ARSO in 1977).

In 2006, 30,000 experts from around the world sat on ISO technical committees, while the organization itself maintains functional links with another 591 INGOs. We could see this network not only as embedded in transnational civil society, but also as a transnational technical infrastructure which – in common with most infrastructures – supports essential aspects of modern life out of sight and out of mind for the great majority of its beneficiaries.

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broadcasting; car safety standards; engineering; European Union (EU); food safety standards; intergovernmental organizations; international non-governmental organizations (INGOs); labour standards; League of Nations Health Organization; League of Nations system; mail; measurement; music; organization models; Pax Americana; radio; railways; regions; technical assistance; technologies; telephone and telegraphy; trade; trade (manufactured goods); trademarks; United Nations decades and years; United Nations system; war