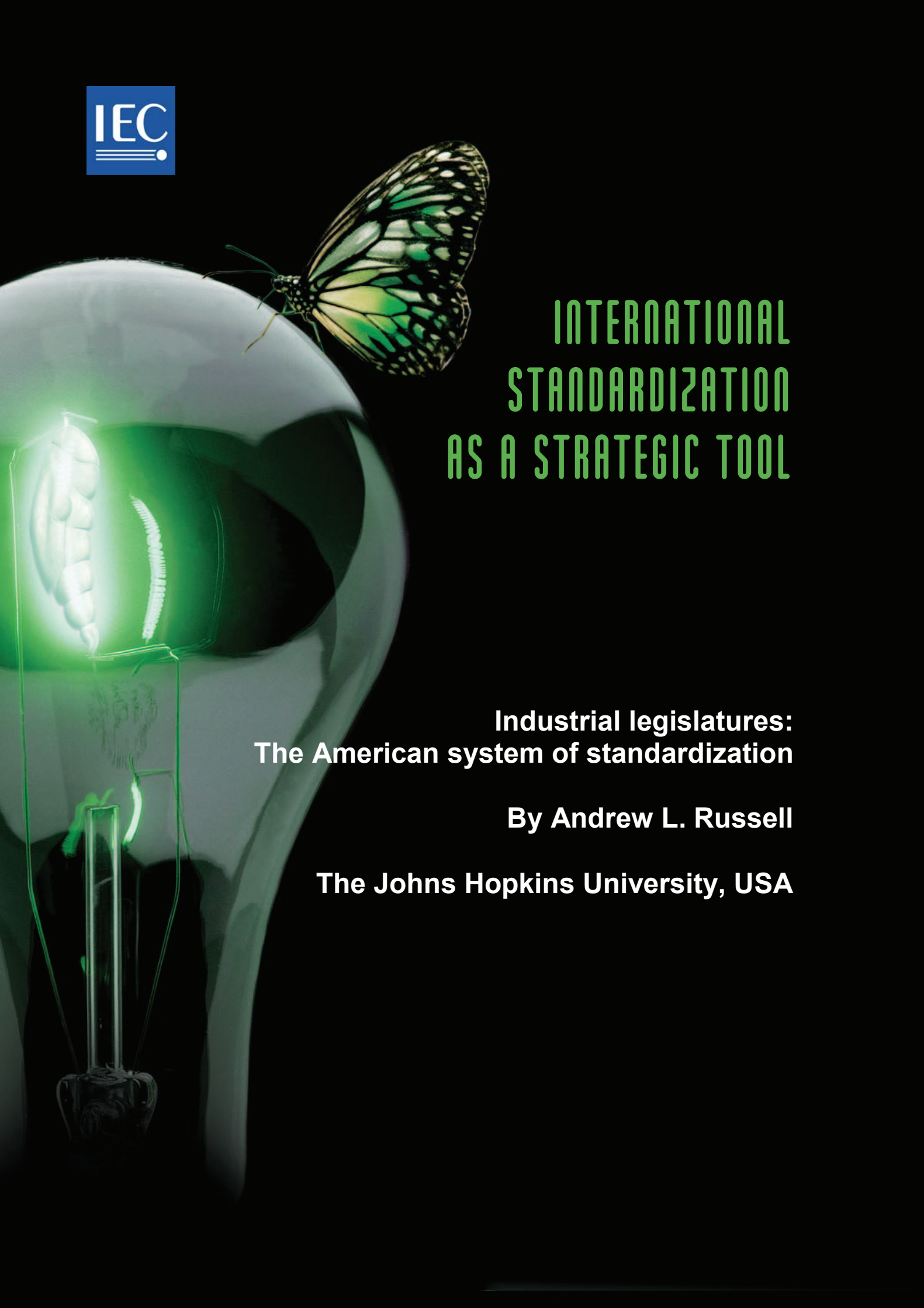

INTERNATIONAL STANDARDIZATION AS A STRATEGIC TOOL

Industrial legislatures: The American system of standardization

By Andrew L. Russell

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The Johns Hopkins University, founded in Baltimore in 1876, was the first university in the Western Hemisphere to be founded on the model of a European research institution, where research and the advancement of knowledge were integrally linked to teaching. Its establishment started a revolution in U.S. higher education. The university is named after its initial benefactor, Baltimore merchant Johns Hopkins, whose US$ 7 million bequest - the largest U.S. philanthropic gift of that time - was divided evenly to finance the establishment of both the university and The Johns Hopkins Hospital. Today, the university has more than 19 000 full-time and part-time students, based on three major campuses in Baltimore, one in Washington, D.C., one in Montgomery County, Maryland, and facilities throughout the Baltimore-Washington area and in China and Italy.

The History of Science programme at the Johns Hopkins School of Arts and Sciences began in 1962. The department has since expanded to include the history of technology as well as main branches of science (physics, chemistry, and biology). It focuses on science and technology since the Renaissance and is strong in the history of American science and technology, the history of early-modern alchemy and chemistry, Asian science and technology, and museums and modern society.

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Summary

As the International Electrotechnical Commission celebrates 100 years of collaborative effort, my contribution to this moment of centenary self-reflection is to trace the historical evolution of the American system of standardization.

Much like the history of the American nation itself, this American system of standardization has strong traditions of voluntarism, local control, meritocracy, rights to represent one's own interests, and a marked preference for private coordination of commercial activity. By the first decades of the 20th century, the range of standard-setting institutions in many respects resembled our situation today: a decentralized and pluralistic constellation of institutions, each pursuing standardization to suit their own objectives within a dynamic and competitive international context.

My approach to the history of the American system of standardization—and its significance for international standardization—is to focus on ideas and institutions. There are striking similarities between the challenges that faced proponents of industry standardization in the early 20th century and those who aimed to advance the cause of consensus standardization in the late 20th century. Both historical contexts are marked by constant jurisdictional conflicts, complex technical problems, a competitive international economy, and the continual need to negotiate boundaries between government control, market activity, and collaborative institutions.

Today's solutions are responses to yesterday's problems. I hope that this paper will help readers think about how yesterday's problems—and yesterday's solutions—are still with us today.

1 Introduction

At the beginning of the 21st century, a consensus had emerged among most observers of the global mobile telephone industry: Europe got it right, and America got it wrong. The Europeans, thanks to the leadership from the European Union, had rallied industry and government support behind a single digital network standard—GSM—that propelled European firms to global leadership. The Americans, having placed their faith in the wisdom of "the market," had been rewarded by a dizzying array of incompatible network standards, a frenzy of corporate mergers and alliances, and sluggish consumer adoption.

Critics were quick to pronounce the American approach a "great failure," which they attributed to a Reagan-era free-market ideology, leadership failures on the part of the Federal Communications Commission (FCC), and an industry still reeling from the 1984 breakup of AT&T.[1][1] In my opinion, these factors were important, but they do not provide a satisfying explanation for why the American

[1] Figures in square brackets refer to the Bibliography.

industry developed the way it did. In this essay, I suggest that an appreciation for the historical dimensions of standards in American industry might lead us to be more sympathetic with the FCC's choice. The FCC's decision to defer to the collective judgment of professionals in the private sector was not, as the critics suggested, a mindless or incompetent act. Rather, it was a recent example of an American approach to technical standards whose roots lie in the late 19th and early 20th centuries.

Much like the history of the American nation itself, this American system of standardization has strong traditions of voluntarism, local control, meritocracy, rights to represent one's own interests, and a marked preference for private coordination of commercial activity.[2] Americans pursued standardization in a variety of institutional settings in the 19th century, and the stable contours of an American system of standardization were in place by 1930. The system consisted of loosely affiliated networks of institutions, featuring government participation but lacking overarching government control, that helped engineers and executives in a wide range of industries reduce inefficiencies and create platforms for further innovation and production.

As we celebrate a century of standardization in the International Electrotechnical Commission, a pause to study our history seems appropriate. Today's solutions are responses to yesterday's problems. In this spirit of historical self-reflection, my aim for this paper is to push readers to think about how yesterday's problems—and yesterday's solutions—are still with us today.

2 Electrical standardization in the 19th century

Standards are of obvious importance in the history of the electrical industries, and have been so for over 100 years. Electrical standardization in the modern world arose out of diffuse institutional settings, including scientific investigations, private manufacturing, and government laboratories. Electrical engineers and scientists have always understood that standards were not exclusively technical matters, but rather technically oriented instances of diplomacy, with a heavy dose of international prestige and commercial power on the line.

Beginning in the 1860s, British physicists, electrical scientists, and telegraph engineers met under the auspices of the British Academy for the Advancement of Science to establish precise and consistent units of resistance. The leading lights of electrical science participated in the British Academy's Electrical Standards Committee, including James Clerk Maxwell, James Joule, J.J. Thomson, and William Thomson (later Lord Kelvin). Their collaboration also included significant contributions from the German, Werner von Siemens, as well as the distinguished American physicist, Henry Rowland. The topic of standardization drew such an illustrious crowd because control over standards meant control over electrical telegraphy networks used by the British to administer and extend their global empire. In a very real sense, control of the world depended upon control of electrical standards.[3]

This collaboration laid the technical and organizational foundations for extensive electrical standardization in the International Electrical Congresses that first met in Paris in 1881.[4] At the 1904 Congress in St. Louis, the leaders of these Congresses (including the British inventor and engineer, Colonel R. E. B. Crompton, Lord Kelvin, and the American entrepreneur, Elihu Thomson) created the International Electrotechnical Commission (IEC) as a representative body that could bring the "cooperative spirit that animates electrical workers" into a formal and permanent organization.[5]

Another group of powerful institutional actors—government laboratories—soon entered the arenas of national and international standardization. In 1887, Germany established the first government institution dedicated to the production of standards through laboratory research.[6] The success of the German Imperial Institute soon stimulated institutional imitators abroad, including the British National Physical Laboratory (founded in 1899) and the American National Bureau of Standards ("Bureau of Standards", founded in 1901). The Bureau of Standards focused its efforts narrowly on standards for weights, measures, heat, and optics; but it soon expanded its mission to include

electricity research as well as testing of materials quality, and also provided technical assistance and product evaluations for regulatory bodies.[7]

As the Bureau of Standards began to establish its role in the early 20th century, American engineers in the private sector recognized that they needed to take positive steps in order to keep industrial standardization initiatives under their jurisdiction. Consequently, they began to create new institutions to establish standards, and brought with them the strategic, technical, and administrative experiences they gained from earlier standardization efforts in industry, science, and government. Through these institutions, they created a fluid system to control standardization for established, emerging, and unimagined electrical technologies.

3 Electrical standardization: American Institute of Electrical Engineers

American engineers in the late 19th century created a number of national professional engineering organizations along specialized lines, including the American Society for Civil Engineers (ASCE, founded in 1852), the American Institute of Mining Engineers (AIME, founded in 1871), the American Society of Mechanical Engineers (ASME, founded in 1880), and the American Institute of Electrical Engineers (AIEE, founded in 1884). Within these societies, engineers developed a professional group identity that included commitments to social responsibility and mutual cooperation as well as the objective application of scientific knowledge to advance material and social progress. Standardization provides the clearest expression of the mix of scientific and commercial values at the heart of these professional engineering societies, and the AIEE's history shows how these values could be mobilized to create a legitimate and effective institution for setting standards. The proponents of standardization understood that technical specifications would be most effective only through widespread (if not universal) use. To achieve such wide-spread adoption, engineers and corporate managers needed to be convinced that their self-interest would be served through the adoption of these standards.

The appeal of standardization for engineers and executives in the American electrical industries stemmed from its potential to advance their respective technical and commercial interests. Where engineers such as Charles Proteus Steinmetz at General Electric advocated standardization because it facilitated greater coordination and systematization, executives such as Chicago Edison boss Samuel Insull favoured standardization because it helped simplify factory operations and reduce costs.[8] The concentrated structure of the electrical power industry also worked in favour of industry-wide standardization: although Thomas Edison and George Westinghouse had locked horns in the "battle of the systems" between direct current and alternative current, this battle was resolved by 1892 with the introduction of polyphase current systems. By the 1890s, according to historian Thomas P. Hughes, technical relationships in the industry were characterized by a "spirit of flexibility and compromise among the various utility interests, and especially among the manufacturers."[9]

This cooperative spirit, combined with the professional aspirations of university trained electrical engineers, led to the creation of a national electrical engineering association, the AIEE, in 1884. With the International Electrical Exhibition scheduled to be held in Philadelphia later that year (hosted by the Franklin Institute), American electrical engineers wanted to have a formal body in place to receive the scores of prestigious foreign electrical scientists expected to visit. Founding members of the AIEE included the telegraph engineers Norvin Green (who was the society's first president) and Elisha Gray; telephone engineer-managers Alexander Graham Bell and Theodore Vail; and the lighting engineers Charles Brush and Thomas Edison. This roster of founders hints at two enduring characteristics of the AIEE in its first decades: its close contacts with the business community, and the technical sophistication and elite status of the growing American electrical profession.[10]

In his history of the AIEE, A. Michal McMahon suggested that standards work "held special meaning for the first generation of professional electrical engineers. As Steinmetz and others would argue, the standards process suggested a social standard as well as a technical one. It embodied the early electrical engineer's cherished social value: coordinated activity."[11] This coordination

occurred within the AIEE as well as between the AIEE and other institutions active in electrical standardization. For example, the AIEE's first standards activity began after an approach in 1885 from two trade associations, the National Telephone Exchange Association and National Electric Light Association, that sought support for their standard wire gauge. In 1889, the AIEE formed its own Committee on Units and Standards, with Edison Electric consulting engineer (and later Harvard and MIT Professor) Arthur Kennelly as chairman.

By 1906, AIEE members had achieved substantial success in their various standardization projects. These were not primarily technical achievements, but rather administrative and diplomatic, such as the AIEE's assistance in the creation of the National Bureau of Standards and its role in organizing the International Electrotechnical Congresses in Chicago (1893) and St. Louis (1904).[12] McMahon also celebrated the AIEE's status as a model technical society and standard-setting body: "AIEE engineers would be able to declare on the eve of World War I that their standardization efforts provided an ideal model of the cooperative spirit in action."[13] In 1963, the AIEE merged with the Institute of Radio Engineers to form the Institute of Electrical and Electronics Engineers (IEEE), which has grown in size and influence ever since. Today the IEEE has over 365,000 members in over 150 countries, and is a world leader in publications and standard-setting for the electronics, telecommunications, and information technology industries. It is safe to conclude that this organization has been successful in its multifaceted mission that began in the late 1800s—to provide a high-status forum for American electrical engineers, and to direct a spirit of cooperation toward commercial applications of electricity.

4 From industry standards to national standards

By the first decade of the 20th century, then, we can already see a spectrum of standard-setting institutions that in many respects resembles our situation today: a decentralized and pluralistic constellation of institutions, each pursuing standardization to suit their own objectives within a dynamic and competitive international context. Standards committees (in groups such as the AIEE, ASME, and ASCE) multiplied quickly throughout the first decade of the 20th century. By World War I, over 100 private organizations—including the engineering societies mentioned above as well as trade associations and international bodies such as the IEC—were creating and disseminating industrial standards. In several cases, however, this proliferation of standards committees ironically began to undermine their underlying purpose of providing greater cooperation and organization. Confusion was especially acute in technologies where four or five different committees issued standards, for example in electrical machinery, screw threads, and pipe threads, without any systematic or formal channels of communication or coordination.[14]

American engineers, inspired by the benefits of cooperation that they experienced during the First World War, devised an organizational solution to meet these challenges of technological compatibility. In 1918, members from the four leading engineering societies—the AIEE, ASCE, ASME, and AIME—combined with the American Society for Testing Materials (founded in 1898) to create the American Engineering Standards Committee (AESC). Comfort Avery Adams, a long-time member of the AIEE Standards Committee and Harvard professor of electrical engineering, was elected as Chairman. One year later, the AESC appointed a full-time secretary, Paul Gough Agnew, who would serve in that position for nearly 30 years. Agnew's dedication and character were key factors in the survival and success of the AESC—and American and international standards more generally—from the 1920s through the 1950s.

The development of specific standards occurred within AESC sectional committees that were organized along industry lines.[15] AESC committees were designed to be open to representatives from all walks of industrial life—including engineering societies, government departments, trade associations, state legislatures, insurance and safety organizations, and private companies—as a way to ensure that all opinions could be heard before a definitive national standard was created. AESC Secretary Agnew coined a political metaphor to describe this feature of the standardization process: "Each of these sectional committees… is essentially a miniature industrial legislature organized upon a subject basis instead of upon a geographical basis."[16] This federation of "industrial legislatures" was an organizational strategy as well as a manifestation of a democratic

political philosophy. In a 1926 article printed in *The New Republic* entitled “A Step Toward Industrial Self-Government,” Agnew argued that this method of standardization had “all the directness and vitality of elementary local self-government.” He continued:

> “We do not leave to Congress, or to the vote of 110,000,000 people, the decision whether a bridge shall be built in the city of Oshkosh. We leave it to the people of Oshkosh, who will walk over it and ride over it, and who will have to pay for it. Why should not the very limited groups directly interested in each of the innumerable industrial problems with which they are faced, themselves solve these problems through cooperative effort?”[17]

The AESC put this principle of self-government to work through its sectional committees. When a sectional committee finished work on a “recommended practice” or “tentative standard,” it would submit the proposed standard to the main committee of the AESC. The main committee did not pass judgment on the technical content of the proposed standard. Instead, it only checked to see if the sectional committees followed a fair and representative process that addressed the concerns of all interested parties—in short, to verify the legitimacy of the “industrial legislature”. Once the main committee concluded its evaluation, the proposal needed to have 90% of the main committee votes in its favour to be published by the AESC as an “American standard”.

The dramatic growth of the AESC membership is a telling indication of the organization’s immediate success. In 1919 and 1920, representatives from the five founding societies were joined by representatives from trade associations, insurance groups, and three government departments (including the Director of the National Bureau of Standards). Due to the heightened interest in standardization by trade associations, membership grew quickly: of the 350 organizations participating in AESC activities in 1928, almost 300 were trade associations.[18] Throughout this initial decade of rapid growth, the main challenge facing the AESC was to maintain a balance of power between the AESC and its member societies. Such a balance seemed the only way to establish the AESC as an effective and legitimate organization while still preserving the power and prestige of member societies.[19]

Major reforms to maintain a workable balance that could sustain a flexible and robust system for creating American industrial standards occurred in 1928, when the AESC reconstituted itself as the American Standards Association (ASA).[20] The immediate introduction of three new faster and more flexible methods in the ASA signalled an effort to meet the needs of the trade associations that represented thousands of private companies. Judging from the surge of financial support from leading industrial firms—in 1928, executives from AT&T and Bethlehem Steel led a fund-raising campaign that added $250,000 to the ASA budget within ten years—this reorganization helped to consolidate the ASA’s legitimacy and status in the eyes of industry.[21]

5 Consensus standardization and the history of the 20th century

What, then, is the historical significance of the AESC? Do their experiences with electricity and steel in the early 20th century have anything to tell us about our adventures with electronics and silicon in the early 21st century? The main contributions of the AESC were its procedural and institutional innovations. Through the efforts of leaders such as Comfort Adams and Paul Agnew, the AESC embodied a cooperative engineering philosophy that it maintained through a loose and flexible federation of organizations. The AESC pioneered an inclusive process designed to foster a national “consensus of those substantially concerned” with the scope and provisions of a proposed standard.[22]

Thanks to the AESC’s institutional experimentation and reform in the 1920s, by 1930 the American Standards Association had achieved legitimacy and stability in the eyes of the leaders of American industry and government. With the “consensus principle” as its pole star, the fundamentals of the ASA’s structure and process remained intact during the subsequent eras of heavy government intervention in the American economy, including the New Deal, World War II, and the creation of the Cold War military-industrial complex. This state interventionism peaked by the late 1970s, with

officials under Presidents Jimmy Carter and Ronald Reagan taking an active role in “deregulating” the American industrial economy, thus leaving the actors in the private sector to devise their own solutions to economic stagnation and international competition.

By the 1980s, a renewed focus on collaboration in the private sector—combined with a relaxed attitude on the part of American antitrust officials—led American policymakers to look anew to the sort of private collaborations that had been fostered since the 1920s through the consensus standardization process. As the historian David Hart has noted, a federal focus on “industrial competitiveness” in the light of competitive threats from Japan and the prospect of a unified European economic bloc led the American Congress and Reagan administration to initiate a new round of associative programmes (or “public-private partnerships” in the new policy jargon), most notably in the shape of Cooperative Research and Development Agreements (CRADAs), the new Advanced Technology Program within the National Bureau of Standards, and the SEMATECH consortium for semiconductor manufacturing.[23]

This friendly ideological climate has helped American advocates of voluntary consensus standardization to advance their cause with tremendous success. For example, the Office of Management and Budget has maintained rules since 1976 that call for the use of voluntary consensus standards in federal procurement; the Office of Technological Assessment in the United States Congress issued an influential 1992 report underlining the importance of standards as the “building blocks” of the global economy; and the Congress has continually passed and revised laws that sanction and encourage the development of voluntary consensus standards without fear of antitrust prosecution.[24]

There are striking similarities between the challenges that faced proponents of industry standardization in the 1920s and those who aimed to advance the cause of consensus standardization in the late 20th century. Both historical contexts are marked by constant jurisdictional conflicts, complex technical problems, a competitive international economy, and the continual need to negotiate boundaries between government, market activity, and private collaborations. For our present purposes, then, the lasting historical significance of the AIEE and AESC came through their translation of the traditional values of engineering cooperation into institutions that operated under principles that require openness, balance, transparency, consensus, and due process.

In the 1920s, as in more recent times, these principles were advanced and protected by leaders and liaisons in the standards process—those who ensure the smooth operation of voluntary consensus process, and whose loyalties cross over the boundaries of multiple organizations. Two early protagonists in the AESC, Comfort Adams and Paul Agnew, are excellent examples of these types of individuals who were active in the 1920s. More recently, one might view the vastly experienced engineers Thomas Haug (a leader in the development of European cellular standards) and Vinton Cerf (a pioneer of Internet standards) as similar sorts of figures who are widely respected not only for their technical abilities but also for their administrative achievements. Haug, Cerf, and many others who worked alongside them in the standardization process all played key roles in the development of global industrial legislatures that maintain standards for the networks that sustain our digital world.

6 Conclusions

Having revisited some key ideas and institutions in the history of voluntary consensus standards in the United States, let us look again to the 1980s and reconsider the decision of American regulators to leave the standardization of digital cellular networks to actors in the private sector. In late 1983, the Bell System was on the verge of divestiture and many Americans were concerned that their world-class telecommunications system would fall into a state of disrepair. As the FCC contemplated how to ensure the technical coordination of the national telephone network, it decided to turn to a new industry group called the Exchange Carriers Standards Association (ECSA). The ECSA’s legitimacy was in part a function of its size: firms in the ECSA served 95% of American customers. In response to an FCC proceeding on standards in the post-monopoly era,

the ECSA volunteered to sponsor a committee that would follow ANSI guidelines for openness, due process, and balance of interests. With the approval of the FCC and the industry, the ECSA created committee T1 in February 1984.[25] This group, much like the AESC in the 1920s, provides an example of American engineers and executives in the private sector maintaining control over industrial standards.

By 1988, this new reliance on voluntary partnerships in the private sector had worked well enough for the FCC to once again turn to the industry to set standards, this time for cellular networks. The FCC also had cause to be sceptical of its own competence for setting standards, given its mishandling of standards for AM stereo in the early 1980s.[26] Mindful of these recent experiences, the FCC turned to two industry groups—the Telecommunications Industry Alliance (TIA) and the Cellular Telecommunications Industry Alliance (CTIA)—to coordinate the development of cellular standards. The CTIA had just been formed, but the TIA was a direct descendant of the venerable Radio Manufacturers Association, which was formed in 1924 and renamed the Electronic Industries Association in 1957. These organizations earned the trust of the FCC and the industry due to their longstanding service in the industry (in the case of the TIA) and their adherence to the ANSI consensus process. In contrast to the critical appraisals of this situation as an organizational failure or market free-for-all, the coordination of cellular standards in the United States occurred within mature, sophisticated, inclusive, and trusted coordination mechanisms.[27]

The common threads between each of the institutions I have discussed—including the AIEE, AESC, T1, and CTIA—are the engineers engaged in negotiations over technical specifications: people with specialized knowledge who were committed to a fusion of the values of democracy and meritocracy. In addition to the institutions mentioned above, the other major players in standardization for the technologies at the heart of our digital society—including the Institute of Electrical and Electronics Engineers, the Internet Engineering Task Force, and a variety of industry groups such as the World Wide Web Consortium—also rely upon consensus-based procedures that draw directly from the procedures developed decades ago in the AESC and ASA.[28]

Taken together, the consistent emphasis on the consensus principle across each of these organizations demonstrates the enduring spirit of voluntary cooperation at the heart of a competitive economy that has characterized the American system of standardization since the late 1800s. The United States has never established a centralized, overarching authority responsible for creating and enforcing standards. Instead, the United States has consistently followed an approach that, according to the economist Jay Tate, is “by far the most institutionally heterogeneous and fragmented of all advanced industrialized countries.”[29] What may appear to the untrained eye to be chaos is in reality a dynamic and flexible system, albeit one that must persevere in a perpetual state of controversy and conflict. The cellular industry’s state of jurisdictional cooperation and competition is one example of a new liberalized and pluralistic regime that scholars have observed in standardization for electronics, telecommunications, and information technology.[30] As this order extends its control over standardization in the foreseeable future, we would be wise to reflect on where we have been as we contemplate where to go next.

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