Centre for International
Governance Innovation

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Big Data Analytics Need Standards to Thrive

What Standards Are and Why They Matter

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67 Erb Street West
Waterloo, ON, Canada N2L 6C2
www.cigionline.org

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About the Author

Michel Girard is a senior fellow with CIGI's Global Economy Program. Michel's work at CIGI relates to standards for big data and artificial intelligence (AI). His research strives to drive a dialogue on what standards are and why they matter in these emerging sectors of the economy. He highlights issues that should be examined in the design of new technical standards governing big data and AI in order to spur innovation while also respecting privacy, security and ethical considerations. He will offer policy recommendations to facilitate the use of big data and AI standards and their incorporation into regulatory and procurement frameworks.

In addition to his work at CIGI, Michel provides standardization advice to help innovative companies in their efforts to access international markets. He contributes to the CIO Strategy Council's standardization activities and was recently appointed to the International Electro Technical Commission's Market Strategy Board, which develops and maintains more than 10,000 international standards for electrical and electronic technologies.

Michel has 22 years of experience as an executive in the public and not-for-profit sectors. Prior to joining CIGI, Michel was vice president, strategy at the Standards Council of Canada where he worked from 2009 to 2018. Previously, he was director of the Ottawa office at the Canadian Standards Association, director of international affairs at Environment Canada, corporate secretary at Agriculture Canada, and acting director of education and compliance at the Canadian Environmental Assessment Agency. He holds a Ph.D. and a master's degree in history from the University of Ottawa.

About the Global Economy Program

Addressing limitations in the ways nations tackle shared economic challenges, the Global Economy Program at CIGI strives to inform and guide policy debates through world-leading research and sustained stakeholder engagement.

With experts from academia, national agencies, international institutions and the private sector, the Global Economy Program supports research in the following areas: management of severe sovereign debt crises; central banking and international financial regulation; China's role in the global economy; governance and policies of the Bretton Woods institutions; the Group of Twenty; global, plurilateral and regional trade agreements; and financing sustainable development. Each year, the Global Economy Program hosts, co-hosts and participates in many events worldwide, working with trusted international partners, which allows the program to disseminate policy recommendations to an international audience of policy makers.

Through its research, collaboration and publications, the Global Economy Program informs decision makers, fosters dialogue and debate on policy-relevant ideas and strengthens multilateral responses to the most pressing international governance issues.

Acronyms and Abbreviations

AI	artificial intelligence
GDPR	General Data Protection Regulation
IAF	International Accreditation Forum
ICT	information and communications technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunications Union
SDOs	standards development organizations
WTO	World Trade Organization

Executive Summary

With data now considered by some to be the "new oil," civil society, industry and governments need to begin setting and implementing international foundational standards. There is an urgent need to set the ontology, semantics and definitions; define measurement and metrics; agree on dos and don'ts and the ethics of big data; and establish testing and certification programs to spur innovation and reap the benefits of big data analytics,[1] all while respecting privacy, health, safety and security, as well as sovereignty rights. Complacency is guaranteed to further exacerbate threats on safety and security, fundamental human rights, public institutions and democracy. It could result in engineering, infrastructure and/or public safety failures. If history in the deployment of disruptive technologies is any indication, taking a passive approach will ultimately result in state intervention and in a patchwork of regulations, rules, review and permitting programs, and, worse, unintended harm to people. Given the stakes, it will be important to set standards through open platforms in order to encourage broad participation and transparency in negotiated rulemaking in order to adapt to the cultures of communities of practices engaged in big data analytics and to generate a broad base of support and compliance.

Introduction

If big data analytics is indeed the new oil, then new rules are needed to provide comprehensive guidance across value chains. New standards, specifications and conformity assessment programs are required, along with changes to administrative/contract law, new legislative frameworks and international agreements. As big data analytics will not be limited to social media platforms and will encompass all sectors of the economy and social protection and policing functions of society, standards will have to address personal data and data generated by sensors and other mechanical devices as well as digital feeds, including still images and camera feeds and facial recognition technologies. Issues such as consent and scrubbing requirements, anonymization, data quality and consistency will need to be standardized in addition to data consent, ownership, collection, processing, aggregation, transmission, storage, analysis, certification and disposal.

The current lack of standards acts as a significant barrier to the growth of big data analytics. Recent surveys on corporate big data uptake show that some organizations are experimenting with new uses for the information they already own and control; a few projects aiming at using data generated by other bodies, such as government departments and agencies, are also beginning to take shape.[2] But the supply of data is elusive as data owners and custodians remain hesitant to share data, for good reason.

A comprehensive standards framework would encompass the following categories of normative documents:

- "foundational" standards to set general rules applicable to all sectors, such as how data is classified (these could be incorporated by reference in regulations as requirements for firms operating in that domain and in public and private sector procurement documents);
- standards that define criteria for establishing the trustworthiness and integrity of data and data sources and other aspects of the big data life cycle;
- standards and specifications to deploy specific platforms, products and applications that would reflect requirements set in foundational standards;
- ethical codes of conduct and public-facing transparency programs outlining accountability requirements; and
- conformity assessment/accreditation and other measurement programs to demonstrate compliance with foundational standards.

1 This paper refers to big data *analytics* to encompass algorithms, artificial intelligence (AI) applications and automated decision-making systems as well as human interventions and combinations of AI and human interventions through hybrid applications. It is assumed that standardized guidance will be required for all forms of analytics and that organizations are accountable for decisions stemming from big data analytics, whether generated by machines, humans or a combination of both. See European Commission (2018); Moerel and Storm (2018).

2 See Enterprise Management Associates® (EMA™) and 9sight Consulting (2014).

As many of the issues that big data analytics can address are global in nature, a push for the use of data sources across national borders should be expected. There is an opportunity to jointly design and implement international foundational standards[3] to facilitate the use of data sets across nations while protecting the sovereignty of national states. Regulators and industry alike want international frameworks to be developed to support a healthy commercial or sharing ecosystem that works seamlessly across national borders. Industry will also see value in having internationally recognized standards and conformity assessment programs that specify how companies can presumptively comply with the regulatory principles.

Five factors have been identified in favour of international foundational standards in emerging sectors such as big data analytics:

→ Innovation is outpacing legal and regulatory frameworks and the ability of regulators to respond to new issues associated with the deployment of disruptive technologies.

→ New laws and regulations are required. Governments are developing approaches to frame new issues on their own, but fundamental principles are not harmonized around the world, leaving both regulators and industry unsure of how to enforce or comply. Inconsistencies in approaches are adding costs for implementation and lack of compliance due to conflicting requirements.

→ Big data analytics will become embedded in all industries, including traditional market players. While in the past each sector built a standardization framework in silos, market participants now employ legions of information and communications technology (ICT) engineers who will work on big data analytics. Foundational documents can underpin new innovations in all market segments and allow for interoperability.

→ The geopolitical dynamics of increased nationalism are weakening a number of international organizations aimed at supporting globalization through treaties and binding agreements. The international standards development community is one of the few stable institutions that provides an international trust mechanism that can balance essential sovereignty concerns with global trade because it is in the business of developing *voluntary* normative documents. The societal implications of not pre-emptively establishing normative standards that are capable of helping society manage the risks that accompany big data will almost certainly result in unintended consequences of unanticipated harm. The difference between this and historical innovations is the unprecedented rate of progress and innovative possibilities outpacing sober second thoughts.

On the other hand, formal, international standard organizations are no longer the place where most emerging, software-based technical interoperability standardization work takes place. Collaborative development methodologies (i.e., open source development and informal group projects) have become the preferred method for software-based interoperability development. However, while addressing certain industry needs, these approaches generally do not satisfy regulators' need to adhere to more formal international requirements regarding government use of "international standards" developed in the private sector. This is where voluntary foundational standards can add value, by offering a pathway for regulators around the world to regulate big data analytics value chains at a faster pace.

What Are Standards?

Although not visible to the average consumer, standards and conformity assessment activities keep the economy running. Standards describe the importance of a process, product, service or system. They provide a level playing field for industry and help build trust between participants in supply chains. They cover everything from the size of the simplest screw thread to the most complex information technology network. They serve as a "handshake" between various components of systems and allow for interoperability by ensuring that everyone is following the same standard.

3 Foundational standards refers to purpose-built standards in areas where there is new or increased cross-border regulatory interest and where regulators and industry must collaborate to establish workable, fair and responsible oversight of new technologies or innovations.

Standards also play a pivotal role in protecting the health and safety of consumers in a wide number of sectors, including food and consumer products, security, infrastructure and the workplace.

Standards are generally taken for granted by consumers and citizens. Their presence and use make our devices and products work better, for example, by ensuring that the connection between a smartphone and a Wi-Fi network happens. A lack of standards does sometimes get noticed by consumers, for example, when travellers must use adapters to charge electronics in a foreign country, or when clothing or shoe sizes vary from one brand to the next. The push for standardization can lead to government intervention when one market participant refuses to adopt a standard. One example that has been unfolding for the past decade involves European regulators and Apple regarding the use of a common mobile phone charging standard in order to reduce waste from incompatible chargers and cables.[4] Their misuse can result in spectacular failures, for example, when a $180 million spacecraft disintegrated because the wrong measurement standard was inserted into the orbital insertion software by a contractor.[5]

Standards cover a wide spectrum of subjects, from definitions, ontology classifications, metrics, measurement, manufacturing techniques and processes to delivery systems and beyond. They set out requirements, specifications, guidelines or model characteristics that can be consistently applied to ensure that products, materials, processes, systems and services perform as intended — qualitatively, safely and efficiently. Many are drafted in a way that allows another party to test and certify that a product, process or system meets the requirements of a specific standard. Put simply, they make things work, save organizations money, help innovations spread and facilitate efficient trade among provinces, countries, economic regions and the international community of nations.

The International Organization for Standardization (ISO) uses the following definition for technology standards: a "document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.... [Standards moreover] should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits" (ISO, n.d.).

4 See Shah (2018).

5 See https://en.wikipedia.org/wiki/Mars_Climate_Orbiter.

Evolution of the International Standardization System

Thousands of organizations around the world are developing and maintaining more than one million standards and specifications. Many were created at the beginning of the twentieth century to support the emergence of new industrial sectors such as telegraphs, railways, steel, oil, motor vehicles, electricity, plumbing, boilers and pressure vessels, elevators, buildings and appliances. Some standards development organizations (SDOs) specifically focus on health and safety issues stemming from industrialization, such as fire protection or occupational health and safety. Often, national professional associations such as mechanical and electrical engineers, as well as subdisciplines such as gas, water, fire, pressure vessels and elevators, created their own SDOs to develop and maintain the standards they needed to operate safely.[6]

After World War II, new international SDOs such as the ISO were created, and older ones such as the International Electrotechnical Commission (IEC) and the International Telecommunications Union (ITU) expanded their scope as trade liberalization discussions were gaining traction. Competing national standards covering the same products and processes were increasingly seen as non-tariff barriers to trade. Truly international standards were needed to support globalization and international supply chains. Some argue that the international standards development process is similar, in some ways, to international treaty making.

6 The logos of SDOs and conformity assessment bodies accredited by the Standards Council of Canada can be viewed at https://researchmoneyinc.com/wp-content/uploads/2018/01/SCC_PRE_Scale-Up-Through-Standards-Setting_2018-04-06.pdf.

Box 1: Standardization of the Shipping Container

Standardization of the shipping container allowing for intermodal freight transport started in the 1930s with competing US and European standards. In 1957, a US delegation proposed the creation of an international standard to improve the flow of goods. Four years later, the ISO created Technical Committee 104 for "freight containers...terminology, classification, dimensions, specifications, handling, test methods and marking." Seven years later, ISO 668 was published. This revolutionized intermodal shipping by significantly reducing transportation costs, shipping losses and delays. Some economists argue that standardized shipping containers contributed as much to globalization as the World Trade Organization (WTO) agreement itself. Today, there are more than 2.4 million containers in use around the world. Although three types of measurement were included as options in the original standard (US, Western Europe and Eastern Europe), shippers quickly coalesced around containers that fit US truck and railway car sizes as it was the most important market. Other countries had to adapt their equipment and measures to US requirements in order to remain competitive. Once a standard is set, the die is cast. Even today, 50 years after the introduction of the first standard, and with China as the leading manufacturer of shipping containers, sizes are still described in imperial units (8 ft. wide by 8 ft. 6 in. high and categorized in twenty-foot equivalent units or TEU).

As new sectors emerged in the 1960s, additional SDOs and new standardization activities began to support increasingly complex sectors such as plastics and chemicals, business machines, telecommunications, computers and information processing, avionics, laboratory testing as well as services and management systems standards covering quality, risk or the environment.

Most SDOs currently require between 18 and 36 months to develop a new standard. This is due, in part, to the rules governing standards development and to the culture of the organizations and their membership. The standards development, comment and approval process is highly structured, with a mandatory cross-section of stakeholder representation throughout, and codified in specific stages, with built-in timelines for clause-by-clause review, comments and written disposition, voting and balloting.

These structured steps allow stakeholder groups to review, debate, comment, vote, or sometimes block and delay the publication of a contentious document. Before the 1980s, in-depth discussions on various national approaches and best practices in place in different regions of the world had to take place before decisions could be made on the features of a new international standard. Means of communication were slower and less reliable at the time than they are today, forcing participants to meet in person for extended periods of time and to wait for documents to be physically mailed. However, these timelines were accepted because product line cycles were much longer than they are today.

There is also a human dimension to the traditional technical standards development process. Members generally preferred to meet in person in order to build trust, understand other parties' perspectives, discuss issues thoroughly and even review contentious text line by line as a group, which added time to the development process.

One thing is certain: health and safety issues were top of mind for those participating in standards development activities during the industrial age. Clearly, the standardization of pressure vessels, boilers, steel bridges, railways, elevators, pipelines or elevating devices brought costs down and allowed for interoperability. But just as importantly, standards were seen as an effective tool to manage risk, reduce the number and severity of accidents and save lives. Engineers responsible for product design, manufacturers, operators, workers and consumers all had a stake in this. This partly explains why this somewhat plodding process has remained relevant. This is an important consideration to keep in mind as ways to standardize big data and AI are examined.

The development of the standardization system was not centrally planned by any stretch. Most international and industry-specific SDOs began small and remain not-for-profit organizations, even those managing tens of thousands of participants, standards catalogues exceeding 10,000 documents, global sales strategies and hundreds of employees. Many have become complex organizations that need to generate a steady stream of revenues as they do not enjoy government appropriations. Generally, SDOs do not charge large fees for individual members to participate in the standards development process. Many SDOs offer subscription fees for members to access standards in specific categories. Some large international SDOs such as the ISO and the IEC require member participation through national member bodies representing individual countries and charge national member bodies annual fees to participate. Adoption of international standards is done through voting and balloting of individual member bodies (one country equals one vote).

This explains why standards are not free. Once developed, they become copyrighted documents. Standards get published and sold to users. Buyers include all players in supply chains from the producers of raw materials, those who provide parts, components and systems to the manufacturers of assembled goods, product testing laboratories and conformity assessment bodies. Some SDOs such as the Canadian Standards Association or Underwriters Laboratories have subsidiaries that generate revenues by performing conformity assessment services, including prototype product testing and certification. A portion of the profits generated from certification services can be re-invested in standards development activities.

Once a standard is developed, it does not stay static but navigates instead through a periodic maintenance cycle. Technical committees will review the standards under their purview, generally every five years, to make minor amendments and incorporate new features. If a standard requires significant changes, a new edition of the document will be issued. Standards associated with rapidly evolving products can also be updated at any time if required. On the other hand, if no changes are needed following a five-year review, the standard is labelled as stable; there is no need to purchase a new copy of the document.

Principles for Standards Development and Maintenance

Standards are generally developed according to formalized rules that stipulate the processes to be followed involving engineers and other technical experts, regulators and consumer interest groups. While standards are not neutral, they should balance competing interests in order to offer a technical solution that is broadly accepted and shares the benefits of technological compatibility as widely as possible. International standards development bodies follow the WTO's six principles for standards development and maintenance. These principles are abstracted below as they shed light on the philosophy behind technical standards development activities. As will be seen later in this paper, traditional standards development organizations are not developing standards in the same way as organizations coordinating the development, testing and certification of software, apps and internet-based platforms. The paper argues that these principles should be kept in mind as options for the development of technical standards for big data are considered. These principles should apply to all participants in the standards development process.

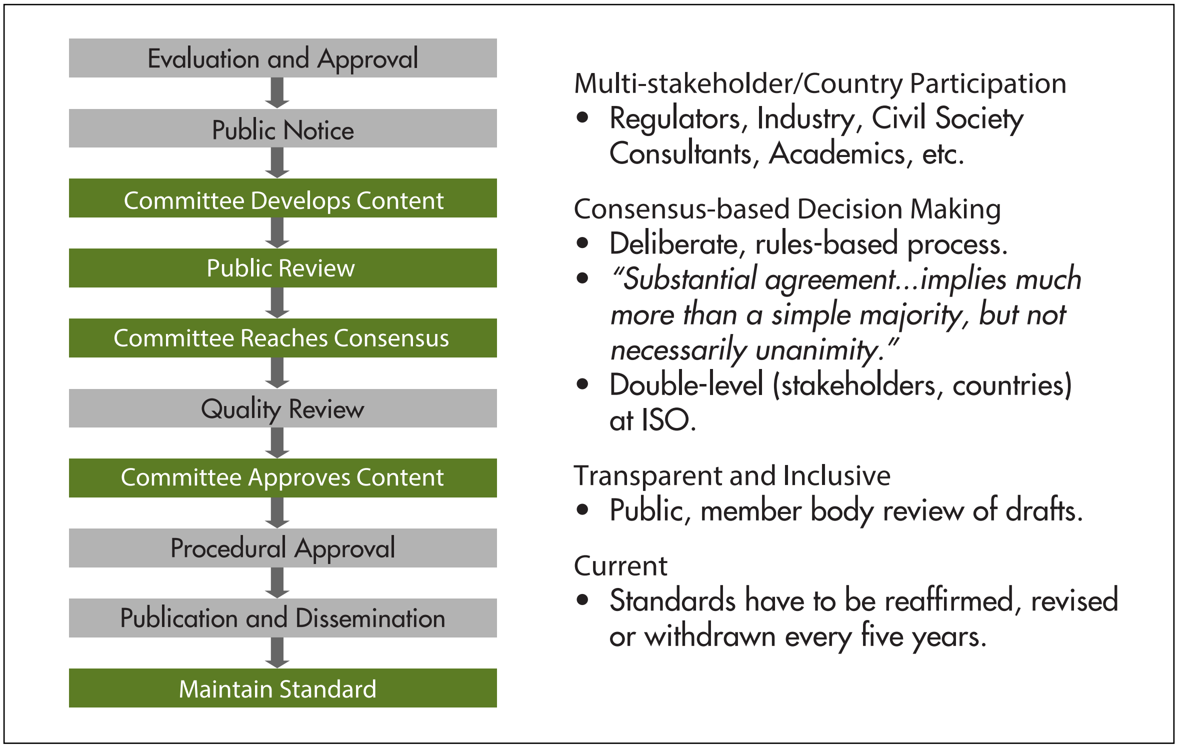
Transparency

All essential information regarding current work programs, as well as on proposals for standards, guides and recommendations under consideration and on the final results should be made easily accessible to at least all interested parties in the territories of at least all WTO members. Procedures should be established so that adequate time and opportunities are provided for written comments.

Openness

Membership of an international standardizing body should be open on a non-discriminatory basis to relevant bodies of at least all WTO members. This would include openness, without discrimination, with respect to the participation at the policy development level and at every

Figure 1: How Standards Are Developed



Source: www.tfocanada.ca/global/File/TFO-Canada_MGirard_2011-05-30-FINAL.pdf.

stage of standards development. Developing country members, in particular, with an interest in a specific standardization activity should be provided with meaningful opportunities to participate at all stages of standard development.

Impartiality and Consensus

All relevant bodies of WTO members should be provided with meaningful opportunities to contribute to the elaboration of an international standard so that the standard development process will not give privilege to, or favour the interests of, a particular supplier or suppliers, country or countries or region or regions. Consensus procedures should be established that seek to take into account the views of all parties concerned, and to reconcile any conflicting arguments.

Effectiveness and Relevance

In order to serve the interests of the WTO membership in facilitating international trade and preventing unnecessary trade barriers, international standards need to be relevant and effectively respond to regulatory and market needs, as well as scientific and technological developments in various countries. They should not distort the global market, have adverse effects on fair competition, or stifle innovation and technological development. In addition, they should not give preference to the characteristics or requirements of specific countries or regions when different needs or interests exist in other countries or regions. Whenever possible, international standards should be performance-based rather than based on design or descriptive characteristics.

Coherence

In order to avoid the development of conflicting international standards, it is important that international standardizing bodies avoid duplication of, or overlap with, the work of other international standardizing bodies. In this respect, cooperation and coordination with other relevant international bodies is essential.

Development Dimension

Constraints on developing countries, in particular, to effectively participate in standards development should be taken into consideration in the standards development process. Tangible ways of facilitating developing countries' participation in international standards development should be sought. The impartiality and openness of any international standardization process requires that developing countries are not excluded de facto from the process. With respect to improving participation by developing countries, it may be appropriate to use technical assistance, in line with Article 11 of the Agreement on Technical Barriers to Trade. Provisions for capacity building and technical assistance within international standardizing bodies are important in this context.[7]

For illustrative purposes, Figure 1 provides a visual on the steps required to develop technical standards by organizations accredited by the Standards Council of Canada. Most developed countries follow similar processes for standards development and maintenance.

Key Features of Voluntary Standards

Standards Are Not Neutral

Participating in standards development means negotiating with others and making choices. It is about balancing the competing interests of those around the table in order to offer a technical solution that is broadly accepted and shares the benefits of technological compatibility as widely as possible. Although everyone can comment on a draft document, technical committee members yield a significant influence over outcomes. The positions of chair and conveners of technical committees and working groups, who hold the pen and lead discussions, are highly sought after.

Setting standards is not about aiming for average performance. Generally, the goal of leading participants in the standards development process is to set the bar slightly higher than current offerings in the marketplace and to aim for higher performance levels. As a result, standards generally end up using, or being based upon, proprietary technologies. The "prize" for participating in the development of a standard may, therefore, to be the first to get to market using the new standard applied to your product, service, or process. You could also "win" by embedding intellectual property you own in the performance features of a given document through either essential, or non-essential, patents and collect licensing fees.

Regarding health and safety requirements, standards generally set the bar to those acceptable requirements in the marketplace. For example, new editions of health and safety standards typically have higher levels of safety than what was required in previous versions of the same document, providing a clear pathway to improvement. This has forced industry and regulators to apply risk-based and evidence-based approaches to assess which proposed additional requirement is the most cost effective and will result in the greatest harm reduction.

Once the Standard Is Set, the Die Is Cast

Participants in the standards development process will say that members invest significant amounts of time before coming up with the first edition of a standard. Entire industrial sectors retool in order to meet new requirements. Prototypes need to get tested and products certified before they can be sold. As a result, committee members are generally wary of starting from a blank sheet when the five-year review process kicks in. Latecomers in the process are generally at a considerable disadvantage to embed their ideas if they are not included in the first edition of a document.

Consumers Benefit in Many Ways

As choices are made over competing ideas, processes or approaches, a new standard will quickly bring about technological and product certainty, which will lower the risk for consumers and for manufacturers. According to Dan Breznitz from the University of Toronto and Michael Murphree from the University of South Carolina: "With standards, and standards-compliant products, users need not fear incompatibility in the goods they purchase. The capabilities of products or services are knowable and reliable *ex ante*. Standardization thus reduces the costs of search and information, improving the functioning of market mechanisms by allowing consumers to make readily informed decisions" (Breznitz and Murphree 2018, 4).

7 See Wijkström and McDaniels (2013, 10-11).

Box 2: Examples of Standards and Codes

The following table gives examples of standards and codes incorporated by reference in federal and provincial Canadian regulations to set health, safety, energy and/or technical requirements.

Topic	Code or Standard	SDO
Electrical	C22 — Canadian Electrical Code	Canadian Standards Association
Natural gas	B149 — Natural Gas and Propane Installation Code	Canadian Standards Association
Boilers and pressure vessels	Boiler and Pressure Vessel Code	American Society of Mechanical Engineers
Pipelines	Z662 — Oil and Gas Pipelines Systems	Canadian Standards Association
Fire detection	ULC S531 Standard for Smoke Alarms	Underwriters Laboratories Canada

Another benefit from the standardization of new products is a shift of the mode of competition from product differentiation to price competition. Again, according to Breznitz and Murphree:

> In a pre-standardization era, competition among products is defined by differentiation. Companies compete to attract unique communities of non-committed users by offering the most attractive option — defined through the best quality of service, range of capabilities, design, robustness or other unique proprietary features.... Once standards are set, however, the nature of competition rapidly changes. Standardization defines the central capabilities of a given technology — capabilities shared by all products regardless of company or country of origin. Where the capabilities are identical, the ability of providers to differentiate the standards-compatible products rapidly declines. Competition thus becomes defined by price as the standardized technologies are now commodities. (ibid.)

A Necessary Complement to Regulations

As the vast majority of technical standards published by SDOs are "voluntary" in nature, market forces dictate their use through supply chain contracts or procurement requirements. There is no obligation to comply with them under regulatory or legislative frameworks, except where suppliers are bound by contract to meet their customer's specific requirements, such as conformity to ISO 9001 or ISO/IEC 15288. Strictly voluntary standards are described as alternatives to regulations.

However, the linkages between "mandatory" standards and regulations are often misunderstood and need further exploration as future technical standards supporting big data analytics will find their way into regulations around the world.

Although practices vary from one jurisdiction to the next, developed countries tend to reference a large number of standards and conformity assessment obligations in regulations. The practice is defined as incorporation by reference. In Canada, comprehensive research by the Standards Council of Canada has unveiled more than 5,500 technical standards and codes referenced in provincial regulations, in addition to more than 1,600 references to technical standards and codes in federal regulations. Examples include regulations covering occupational health and safety, construction and infrastructure energy efficiency requirements, environmental protection, consumer products, electrical, oil and gas, elevators, pressure vessels, medical devices and organic foods.

Compliance to a technical standard referenced in a regulation means compliance with the intent of the legislator. In addition to naming a particular standard, Canadian regulations will often also require third-party certification of a product or a device as an accredited certification body as a demonstration of compliance. There are two main methods of incorporating a standard in a regulation. Either static incorporation, where a particular edition of a standard (including year of publication) is spelled out or, as amended from time to time, where compliance to the latest edition of a given standard is expected.

Regulators sometimes determine that adherence to a given standard is not enough in itself to meet legislative objectives and will spell out additional requirements in the regulations. A "weak" voluntary technical standard can therefore be incorporated in a regulation with additional requirements spelled out. For example, there are many standards covering the energy efficiency performance of consumer goods and appliances. However, some jurisdictions will set the energy efficiency bar higher and spell out amendments to the standards in the regulatory text. This practice gets noticed by technical committees and may result in amendments to subsequent editions of the standard in order to allow regulations to remain relevant.

As the WTO requires parties to eliminate non-tariff barriers to trade, there has been a trend to replace national standards by international standards in regulations when available and when possible. It is very difficult to do so in sectors such as transportation and infrastructure where unique national approaches and requirements have been in place for decades; moving to international standards would require the rebuilding of entirely new systems such as roadways, railways, electricity distribution grids, buildings and networks. However, regulators can adopt international standards when new sectors emerge and require some form of regulations. Recent examples would include standards for photovoltaic solar, wind turbines and interconnection switches as well as electric vehicle charging stations, which have been developed by the IEC and adopted with little or no deviations into national standards in codes and regulations. International standards are also adopted in regulations to manage the safety of new products such as medical devices and electronics.

Using standards as a complement to regulations can provide many benefits to both regulators, industry and consumers:

- → For regulators, there is no need to "reinvent the wheel" when addressing common issues. In the case of electrical safety and interoperability, for example, regulators benefit from participating, along with industry and consumers, in the development and maintenance of a common electrical code that can be adopted by all jurisdictions when a new edition is published. Adopting common standards also meets WTO obligations to reduce non-technical barriers to trade.
- → For industry, the adoption of common standards by regulators reduces the need for multiple testing and certification requirements.
- → For consumers, the adoption of common standards makes it easier to acquire products that can operate in multiple environments and that are certified to perform to a given benchmark with the added advantages of increased competition and lower prices. One of the most critical consumer aspects is trust: standards provide consumers with a basis for trust. Labels and certification marks provide consumers with something to trust and an organization that is accountable for safety, reliability or efficiency claims.

Unfortunately, standards incorporated in regulations are not always aligned between jurisdictions. Delays in the adoption of new editions, choosing different standards for compliance or adding new requirements in regulations occur on a regular basis. For example, in a submission to the Canada-US Regulatory Cooperation Council, the Canadian Institute of Plumbing and Heating asserted that straightforward products such as gas water heaters require four different certifications embedded in provincial regulations to cover the Canadian market of less than 38 million consumers. In contrast, only two certifications are required to cover the entire US market of more than 327 million consumers, and only one would be necessary to cover the European market of more than 600 million consumers (Canadian Institute of Plumbing and Heating 2012).

Conformity Assessment

Once a standard is developed, it is important to ensure it is used as intended. Conformity assessment is a method to determine whether products, services, processes, systems or persons meet specified requirements. Conformity assessment can involve certification, inspection and/or the testing of a product or system. It ensures that products and services are meeting required quality, safety and environmental standards, thus helping to safeguard the health and safety of consumers.

First-party conformity assessment refers to an activity that is performed by the person or organization that provides the object. In the European Union, for example, it is possible for a company to self-declare that their products are in conformity with EU rules by performing tests in house and applying the relevant mark on each product, which bears the letters CE.

Second-party conformity assessment refers to a conformity assessment activity that is performed by a person or organization that has a user interest in the object. It could be that a company hires a consultant to perform tests on a product or a system. It is not used widely for certifying tangible products.

Third-party certification involves contracts between manufacturers and certification bodies whereby prototypes and samples collected during production are tested against specific standards. Compliant products will bear the appropriate certification marks. Non-compliant products would be discarded. Here, the conformity assessment activity is performed by a person or body that is independent of the person or organization that provides the object and has no user interest in the object.[8]

Accreditation and International Mutual Recognition

One of the fundamental objectives pursued by private sector participants in international standardization activities is "one standard, one test, one certification, applicable everywhere." This objective has been driving efforts over the past 70 years, first to "build bridges" between national, regional and continental systems, and then to make concerted efforts to migrate from national to international standards. These efforts were not planned or executed top-down. Rather, they followed market trends toward globalization and longer, more complex supply chains.

In order for products or laboratory test results to be recognized not only in the country where they originate but internationally, a system made up of a series of international mutual recognition agreements administered by multilateral bodies has been established around the world. Organizations such as the International Accreditation Forum (IAF), the International Laboratory Accreditation Cooperation, the Asia Pacific Laboratory Accreditation Cooperation and the Inter American Laboratory Accreditation Cooperation audit their members regularly. They provide an assurance to government, business and the consumer that organizations providing certification to a standard have the required competence and impartiality to do so as evidenced by fulfilment of international standards and requirements. Most national accreditation bodies belong to these international organizations. Periodically, they invite peers from other countries to visit their facilities and audit their staff competencies, operations, quality management systems and complaint resolution processes. A determination can then be made as to whether service levels match international accreditation standards. A successful audit confers a status of accreditation to national accreditation bodies. As a result, it will be easier for products certified under a national accreditation body to be accepted in another country without having to go through duplicative certification processes elsewhere. According to the IAF (2011, 2), "Accreditation helps to underpin the credibility and performance of goods and services."

8 See Woodley (2016).

For product categories that are not subject to national regulations and that are governed by one series of international voluntary standards, the international mutual recognition framework of accreditation bodies appears to be meeting industry needs. However, there are a large number of product categories that are regulated out of health, safety, security or environmental concerns. Although federal and provincial regulators often incorporate standards in regulations, industry generally faces a wide array of additional deviations and requirements to the standards themselves, which are added to regulatory text.

Standardization in the ICT Sector

When it comes to the ICT sector, standard-setting activities can only be described as extraordinarily complex, opaque, evolutionary, bottom up and unpredictable. A number of factors led to the development of new models for setting standards and specifications operating in parallel to traditional standards development organizations such as consortia standards and specifications setting and open source software collaboratives.

In its infancy, the ICT sector (encompassing telegraphs, telephones, cables, radio and spectrum management) followed the same path as other industries and relied on the traditional standards development model. Organizations such as the ITU began to set international interoperability standards for telegraphs in the 1860s, which allowed for the development of a global communications framework. The same path was used to support the deployment of more recent ICT technologies such as the transistor, television, electronic devices and even satellite telecommunications.

However, with digitization in the 1970s came about new approaches for setting standards and specifications to achieve interoperability. Digitization refers to the advent of software, the internet and products such as computers and handheld devices that allow for electronic information to be accessed, stored, transmitted and manipulated electronically. The requirements for this sector were different and unique when compared to other sectors of the economy.

The explosive growth of the World Wide Web, intense competition between organizations for market share, quick product development and obsolescence cycles, increased complexity of products, intense battles to incorporate essential patents into specifications, lack of regulatory oversight (in part because the deployment of these technologies did not appear to generate additional health and safety risks for consumers) and the opportunity to launch new products globally created significant demand for new standards and specifications, but the standards needed to be developed at a pace and a level of complexity that the established standards development organizations just could not meet (Updegrove 2007).

Standards Consortia

Starting in the 1980s, standards consortia organizations began to appear in addition to the established SDOs already operating in that space, culminating in more than 435 ICT consortia developing standards and technical specifications bodies between 1998 and 2012. Approximately 60 percent of standards and specifications covering the ICT sector were created by consortia, including well-recognized interoperability standards such as USB drives, DVDs, the Blu-ray optical disc format, HTML, UHD, XML, MIDI and PCI-Express. Established international SDOs also played an important role by developing other standards such as Wi-Fi, SMS, 4G, XML and MP3 (Biddle et al. 2012, 179).

To give an idea of the scale of the effort required to establish interoperability frameworks to support the commercialization of new products, Brad Biddle and other ICT standardization experts estimated in 2012 that at least 251 interoperability standards are embedded in a modern laptop computer, with many hundreds more needed for communicating information from one device to another through the internet (ibid.).

Standards consortia played an essential role in the rapid deployment of the personal computer, computer software and the internet. Market participants, often frustrated at the slow pace of development in established SDOs, created individual consortia to "create the standard" in new fields when new technologies or processes were ready for market. Tim Pohlmann, who undertook a comprehensive survey of the evolution of ICT sector consortia in 2012, noted that although they differ widely in terms of organizational structures, policies and bylaws, and purpose, consortia are generally smaller in terms of members than traditional SDOs, frequently follow only one purpose of business, are often hierarchical in the decision-making structures and are, in many cases, organized in tiered membership structures (Pohlmann 2014, 37).

Biddle et al. identified the following types of consortia operating in the ICT sector:

- **Single-promoter specifications:** Generally used by individual companies to make a specification available for industry adoption, including a covenant not to assert necessary claims.
- **Contractual consortia:** Where multiple partners jointly develop a specification. Partners enter into promoters' agreements, which address licensing commitments in necessary claims. They can also extend agreements with contributors and adopters once the specification is designed.
- **Incorporated consortia:** Organized around multilateral contracts establishing membership or participation agreements requiring members to abide by the obligations set forth by the consortium bylaws and intellectual property rights policies in exchange for access to the specifications or design guidelines and the benefits of the licensing commitments that accompany them. Incorporated consortia have various levels of membership. Benefits include the right to own and license trademarks and administer certification programs.
- **Hybrid model:** Incorporating elements of contractual and incorporated consortia.

Because consortia are generally tied to one technology, they are more sensitive to technology and market shocks and tend to have shorter lives than traditional SDOs. This explains why most of the consortia created in the 1990s have been dissolved or have been amalgamated with others. Technical committees are generally short lived, and membership fluctuates greatly from one year to the next. As their main objective is to facilitate the commercialization of new products, few consortia followed any of the WTO's six principles, such as broad public participation.

Open Source Software Development

The entire edifice of digitization is based on software development and coding. As this new sector appeared, so did new approaches to draft, test and ensure new products' interoperability from software to code language and apps. Although traditional SDOs are still used to generate rules for broad applications such as cyber security management systems or cloud computing, by and large, software developers shunned traditional SDOs and standards/specifications consortia in favour of open source software platforms. Microsoft, for example, which relied heavily on traditional SDOs to ensure interoperability, testing and certification of products such as cloud computing in the early 2000s, now relies on development platforms such as GitHub to host and review code and build software with a community of 24 million developers. But like consortia, open source development platforms are simply not designed to solicit broad public participation for making choices between various approaches or to integrate social or other considerations as a new product is being designed.

Rather, when a project is assigned to open software development platforms, fundamental questions as to the "whether," the "what" and the "why," and the possible alternatives to an approach have already been answered. Participants are invited to work together to fix bugs and to help on the "how" to ensure new projects actually work as intended when launched, including product design, outreach and marketing. This raises accountability and responsibility issues when software may impact the health, safety and security of users.

There are also a number of not-for-profit and charitable organizations supporting the open source software movement such as the Linux Foundation. Most of these organizations are promoting the free use of software and operating languages although some, such as the Free Software Foundation, aim at the development and use of free software for "having control over the technology we use in our homes, schools, and businesses, where computers work for our individual and communal benefit, not for proprietary software companies or governments who might seek to restrict and monitor us."[9]

9 See https://opensource.com/resources/organizations.

Implications for Big Data Analytics

Since the publication of CIGI's paper on a national data strategy for Canada in February 2018,[10] authorities around the world have been grappling with a wave of incidents involving the improper, unethical or illegal sharing and use of data.[11] The breadth and scale of incidents have resulted in calls for government intervention and new regulations. The European Commission had planned new data privacy regulations for a number of years. In May, the General Data Protection Regulation (GDPR) came into force and received a broad base of support. It establishes a precedent by creating obligations for consent before personal data can be shared and for alerts to individuals following data breaches. In the United States, the State of California recently amended its Consumer Privacy Act to govern how personal data is collected and monetized. Other states are looking at introducing similar legislation. Some have argued that companies, privacy officers, lawyers and others will have to deal with an even more complex and fragmented policy law landscape (Determann 2018). Complacency will result in a patchwork of laws and regulations across jurisdictions and across sectors (Tutt 2017, 84).

In the meantime, organizations that could play a role in creating new big data value chains in different sectors are sitting on the sidelines and waiting for clarity to emerge. The challenge, therefore, is to be proactive in developing international foundational standards that will frame big data analytics in a consistent manner, in order to help create ecosystems where big and small organizations can thrive while complying with existing legislation.

This framework would obviously encompass personal data generated through social media platforms, cellphone operating systems, search engine queries and outputs from a wide variety of sharing economy platforms. These new sectors of the economy have grown exponentially over the past decade and have not been subject to the same level of regulatory scrutiny and reporting as older, more established sectors have.

But big data is not limited to personally identifiable information generated through social media, or through sharing economy web platforms. It encompasses a multitude of data sets and feeds. For example, data is generated in the Internet of Things (IoT) by a wide variety of mechanical devices such as heat, pressure, motion or humidity sensors operated by private sector companies and by governments. Data is generated by camera feeds, used to nudge traffic flows, and by security cameras, used to monitor facilities and venues. Reams of data will come from IoT chips affixed to billions of devices. Existing databases containing medical records, climate information, products and parts inventories, company records, usage data and financial information, as well as data from a multitude of government programs at all levels, could be put to good use, if properly planned with the appropriate safeguards.[12]

Over time, it is hoped that data from multiple sources will be made available, shared, aggregated and analyzed. Aggregation would lead to new diagnostics, new recommendations and, ultimately, different decisions and actions. Good decisions will result in better outcomes, such as increased efficiency or improved products or services. Data owners and custodians may want to reap some of the rewards stemming from good decisions because they provided the raw material that made progress possible. On the flip side, bad decisions, when they occur, may result in economic losses, hazards, accidents, catastrophes and loss of life. By the same logic, authorities will include data owners and custodians in their forensics. They will question data purity, consistency and accuracy. Data owners and custodians will become liable for errors, manipulation or biases.

To be successful, a comprehensive big data strategy should therefore provide consistent guidance for the use and sharing of all forms of data, throughout value chains and across sectors. Clarity and consistency are needed on terminology, definitions and ontology, on measurements and on metrics. Verifiable and enforceable rules and codes of ethical conduct regarding consent, data ownership, aggregation, protection, storage and disposal are also necessary to establish a level playing field and shared accountability.

10 See www.cigionline.org/publications/national-data-strategy-canada-key-elements-and-policy-considerations.

11 See Perrin (2018).

12 See www.gov.uk/government/consultations/consultation-on-the-centre-for-data-ethics-and-innovation/centre-for-data-ethics-and-innovation-consultation.

Foundational Standards to Support Big Data Analytics

The following section outlines some of the key issues that should be addressed by international foundational standards to support the deployment of big data analytics.

Technical Architecture

There are millions of data sets that could be used as a source for big data analytics. Standards will be needed to structure and categorize shared information environments and data sets, including organizing and labelling categories of data sets to support usability, retrievability, explorability and traceability. Big data analytics will involve complex value chains. Just as with traditional supply chains for tangible products, each segment of a given data value chain will have specific roles and responsibilities, which will have to be described and categorized. In addition, data will go through a life cycle from creation to disposal, which will also have to be described and categorized.

Ontology, Semantics, Definitions and Terminology

When industrial sectors were mostly vertical in nature, SDOs developed standards in silos. As a result, a multiplicity of domain-specific semantics, including product terminology, classification and properties were created and maintained, sometimes for many decades. With digitization, information is being generated and exchanged across sectors. This leads to a demand for universal semantics, which should follow a common ontological foundation. Big data analytics are, by definition, higher-level functions and will need to be based on a common ontology. It is a prerequisite for interoperability. The challenge will be to determine whether sectoral semantic definitions and terminologies can be used as sources for higher-level big data analytics vocabulary, or whether an entirely new "language" will have to be developed. For example, the Institute of Electrical and Electronics Engineers (IEEE) recently published a glossary for discussion of ethics of autonomous and intelligent systems. The glossary outlines and contrasts variations for each term from five different disciplines (ordinary language; computational disciplines; engineering; government, policy and social sciences; and ethics and philosophy) and significant differences have been highlighted.[13] One thing is certain, big data ontology will have to integrate additional value-laden concepts that are rooted in philosophy and ethics that will go beyond coding and the integration of "traditional" concepts such as health, safety and security.

Data Owners, Custodians and Controllers

Currently, the majority of data owners, custodians and controllers, including government departments and agencies, are not willing or legally allowed to share or sell, even with "no regrets" caveats, data to third parties. There are concerns as to whether the data they intend to share:

- should be described as "clean" and devoid of errors or biaises that could lead to errors, incidents or accidents downstream and expose them to potential legal actions down the road;
- should be described as "raw" and devoid of manipulation or filtering;
- will be used downstream in an appropriate fashion;
- may result in unintended consequences;
- may provoke the accidental release of sensitive data; or
- could break any laws, including privacy.

Foundational standards for data owners and custodians would address these issues, including objective tests that could be applied to demonstrate compliance and limitations on liability for misuse downstream, which is paramount for data supply creation.[14]

13 See Jordan, Day and Ingram (2017).

14 Data.gov, the home of the US government's open data portal, provides access to more than 302,000 data sets. See www.data.gov.

Data Owner, Custodian and Controller Self-declaration for Metadata Use

Potentially millions of discrete organizations are data owners or custodians. They may wish to share or sell data. A foundational standard that confirms data availability as well as the features of data would be useful. Standardized self-declaration forms for metadata use would allow for discoverability, accessibility, known quality and consistency of data. As trust in data is an important consideration for data users, a self-declaration would establish parameters for grading the trustworthiness of the source and the data itself.[15] It would also allow for the development of data quality rating or grading systems. And it would provide protocols for data sharing. Data generated through devices such as sensors or cameras could be characterized through standardized reporting of siting, design, operations and maintenance of equipment. A standardization self-declaration statement would also help streamline internal approval processes to make data available to third parties. And it would allow for the creation of a data marketplace where various categories, or "grades" of data could be created, tested and certified.

Data Pools, Trusts, Marts and Warehouses

Large companies with multiple offices have already begun to pool data sets into virtual data mart warehouses. But there are few known instances yet where data from various organizations is being pooled and used. Once data owners, custodians and controllers from different organizations begin to share data, data marketplaces will be created. Data will be pooled and aggregated. Data brokers will buy and sell data. A foundational standard on the features of data pools and trusts will be needed.

15 See Saenger et al. (2014).

Personal Data

The absence of foundational standards regarding access and use of personal data represents an important barrier to the growth of big data analytics. For a start, there is no consistency between jurisdictions regarding what constitutes personal information and, as a result, as to what constitutes personal data. Sources of personal data cover a very wide field. Personal information could encompass everything about an individual whose identity is apparent, even years or decades after the individual has died.

In order to avoid the non-authorized release of personal information through multiple data sources, foundational standards are needed for:

→ **Personal data taxonomy**: Personal information can be found in a multiplicity of data sources. It could be generated by individuals (such as a personal profile featured on a social media platform), by government agencies in their interactions with individuals (such as the issuance of social insurance numbers to individuals), by private sector companies through formal contracts (such as insurance policies or banking records), through purchasing agreements (such as transaction records with retailers), by a multiplicity of devices controlled by individuals (such as geolocation features on a cellphone) and by a multiplicity of devices controlled by organizations outside the control of individuals (such as video cameras with facial recognition software in public venues). A foundational standard would list and describe various data categories and sources and provide guidance for personal data generators, owners and custodians to use for appropriate triage and treatment. For example, a standard could help classify what type of data cannot be shared by a third party; data that can be shared only with explicit consent; data that can be shared following aggregation; and, finally, data that can be shared without restrictions. As indicated above, regulators could incorporate such a standard in regulatory instruments and make amendments or deviations to the standards to suit national circumstances and match regulatory requirements.

→ **Individual consent:** Individuals can, and do, choose to allow the use of personal information by third parties through a number of mechanisms. Standards could categorize and segment consent, describe its reach through supply chains, describe mechanisms that activate consent and outline test methods for a third party to demonstrate that requests for withholding information are respected by data owners and custodians.

- **Data aggregation/disaggregation:** Aggregation of data is an approach used to reduce the level of personal information in data sets. A foundational standard could provide a framework to quantify the presence, and level, of personal information in linked sets of data. There is currently no way to determine with certainty if personal information can be gathered in aggregated data. As a result, different levels of aggregation are used by organizations depending on individual risk frameworks. In addition, when the number of linked data sets increases, it may become impossible for human actors to make an informed judgment as to whether aggregated data sets can be manipulated to extract personal information. New technologies, using minimum cohort sizes, differential privacy, homomorphic encryption and privacy-preserving linkages, can address concerns associated with re-identification of individuals from linked data sets. Developing standards for the testing of the technologies and their application would reduce the risk of unintended release of personal information through aggregated data sets.[16]

These are a few examples of topics that would benefit from the development and use of foundational standards to support the supply and sharing of data sets for big data analytics to thrive. Other foundational standards may be needed to manage risk, provide guidance on the storage of linked data sets and alert individuals in the event of a breach or re-identification.

The international community is not starting with a blank sheet; some of the fundamental issues raised by big data analytics have been tackled by international SDOs for other ICT applications and could be adapted to this new sector. Some recent examples include:

- ISO/IEC 19944: Data Flows Use and Categorization;
- ISO/IEC 20889: Techniques for Anonymization of Data;
- ISO 27552, providing an add-on to ISO/IEC 27001 with an international security management standard focusing on privacy management; and
- ISO 38505-1:2017, an international standard providing guiding principles for members of governing bodies of organizations (which can comprise owners, directors, partners, executive managers, or similar) on the effective, efficient and acceptable use of data within their organizations.

These standards are already used by organizations to demonstrate due diligence for compliance with the EU GDPR. Other useful foundational documents are being drafted by the IEEE to support the deployment of ethical AI products through the P7000 series.[17]

Moving Forward

As the sector grows, one should expect the creation of multiple consortia and open software platforms to develop and test related software, products, platforms and applications, using foundational standards to demonstrate compliance with higher-level requirements, thereby facilitating compliance. With the right standards in place, data supply would grow. And if this new sector operates as other, more traditional sectors have, consumers of big data products could make more informed decisions, interoperability would take hold and the market dynamics would shift from market differentiation to price competition.

As indicated above, big data analytics will permeate all traditional sectors of the economy. The need to

16 See Australian Computer Society (2017).

17 The IEEE P7000 series of standards include: IEEE P7000™ — Model Process for Addressing Ethical Concerns during System Design; IEEE P7001™ — Transparency of Autonomous Systems; IEEE P7002™ — Data Privacy Process; IEEE P7003™ — Algorithmic Bias Considerations; IEEE P7004™ — Standard on Child and Student Data Governance; IEEE P7005™ — Standard on Employer Data Governance; IEEE P7006™ — Standard on Personal Data AI; IEEE P7007™ — Ontological Standard for Ethically driven Robotics and Automation Systems; IEEE P7008™ — Standard for Ethically Driven Nudging for Robotic, Intelligent and Autonomous Systems; IEEE P7009™ — Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems; IEEE P7010™ — Wellbeing Metrics Standard for Ethical Artificial Intelligence and Autonomous Systems.

establish stronger connections between software engineers and other communities of practice for the former to better understand users' needs and to integrate a broader range of considerations, such as health, safety and security, in software design has been well documented. In a recent feature article in *The Atlantic*, James Somers (2017) reports on concerns from engineers who are seeing "critical systems that were once controlled mechanically, or by people, are coming to depend on code." According to Nancy Leveson (1993, v) in her seminal work entitled *Safeware*, system safety and software safety should not be separated. Yet, "we are attempting to build systems that are beyond our ability to intellectually manage" as a result of the integration of software into mechanical systems. Software failures are not like failures of components in complex machines. Software does not break. Software failures are failures of process, of understanding and of imagination. And the complexity is invisible to the eye. It is to be expected that big data analytics will add yet another level of complexity to the equation and require a fundamentally new approach that shifts to systems thinking by broadening the dialogue between multiple communities of practice but in real time.[18]

That being said, many programming engineers value the standardization of software and new coding languages in traditional SDOs in order to mainstream their products. [19]

The standardization of big data analytics could provide some assurance of predictable outcomes and trigger price competition among service providers. But because big data is developing quickly across the globe, and because of the high number of potential interested parties with a stake in new standards covering various sectors, the configuration and segmentation of the standards development process will have to be thought through carefully.

For example, big data analytics platforms, products and applications would greatly benefit from third-party certification programs. However, third-party certification of intangible products such as data sets or algorithms will require entirely new approaches. New, virtual identifiers, as opposed to physical marks or labels on a product, will have to be designed for buyers and users to know that the product they use complies with relevant standards. National and international organizations exist for software testing, such as the Canadian Software Testing Board and the International Software Testing Qualifications Board. Such programs could form the basis for the development of new testing and certification programs aimed at big data analytics.

Once developed, foundational standards could also be used as a complement to legislation and incorporated by reference in regulations. It will therefore be important to engage regulators, consumers and privacy experts early in the standards development process for big data analytics to ensure that standards meet the needs of regulators and consumers.

Canada would gain by developing its standardization roadmap for big data analytics. Roadmaps are routinely developed to support standardization activities in emerging sectors. It would inform Canadians from key sectors of the economy on standardization activities currently under way, identify gaps and make recommendations for action nationally, regionally and internationally.

As a first step, a standardization collaborative would be created — a cross-sector coordinating body whose objective would be to accelerate the development of foundational standards and specifications consistent with stakeholder needs. The collaborative may involve more than 100 organizations, including the Standards Council of Canada, the standards development organizations and consortia (national, regional and international) with a stake in big data analytics, innovative companies, academics, regulators and representatives from key sectors of the economy with an interest in the issue and civil society. Through the collaborative, participants would:

→ test the merits of voluntary "foundational" standards supporting big data analytics that would apply across value chains, sectors and nations;

→ gage interest for the use of online, open, collaborative platforms that adhere to the WTO's six principles for standards development in order to adapt to the realities of the market and the practices of the ICT sector;

18 See Leveson (2011).

19 See Wirfs-Brock (2016).

- determine whether regulators would support the development of voluntary foundational standards with the view to consider adopting them in regulatory frameworks in the future; and
- consult with relevant bodies regarding the feasibility of adopting foundational standards as international standards and developing new international conformity assessment and accreditation programs in this area.

The collaborative would work on a standards roadmap outlining the national, regional and international standards landscape for big data analytics, including standards already published and those under development. It would assess gaps and make recommendations for priority areas where additional standardization and/or pre-standardization research and development are needed. The roadmap would allow governments and industry to better ascertain the investments required to develop a sizeable corpus of standards to support big data analytics in each of Canada's key economic sectors. The roadmap would be updated periodically to assess progress and identify emerging issues that require standardization. Priority standards development activities could be identified and acted upon as the document is drafted.[20]

20 See, for example, America Makes and ANSI Standardization Collaborative (2018).

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