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Making Sense of the Smart City Standarization Landscape

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Making Sense Of the Smart City Standardization Landscape

ABOUT THE IEEE STANDARDS EDUCATION E-ZINE

Technical standards are formal documents that establish uniform engineering or technical criteria, methods, processes and practices developed through an accredited consensus process. The purpose of this publication is to help raise awareness of standards, show the importance of standards, present real-world applications of standards, and demonstrate the role you can play in the standards development process. Knowledge of standards and standards activities can help facilitate your professional engineering practice and improve technological developments to meet the needs and improve the lives of future generations.

Serving the community of students, educators, practitioners, developers and standards users, we are building a community of standards education for the benefit of humanity.

Join us as we explore the dynamic world of standards!

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Letter from the Editor

Smart Cities:
Standards Will Ensure

Ever since humans changed their lifestyle from hunter-gatherers to an agrarian society, we have been building fairly complex living arrangements. Early challenges to organize such habitats included access to basic necessities such as water, food, and shelter, which gradually included sanitation, transportation, and commerce. As our ancestors' collective thinking over many centuries evolved to manage habitats for hundreds or thousands in a community to millions in crowded and polluted cities, we have continuously transformed our villages, towns, and cities. Unabated advancement in technology from the invention of the wheel to the latest Internet of Things (IoT) gizmos has empowered us well beyond our individual capacity in pursuit of better lives defined by the basic necessities of modern times. This, in turn, has lead to complex infrastructure in our megacities that depends on perpetual access to energy (power) and the Internet to provide for and operate services such as transportation and to maintain law and order.

As we look at the complexities of many different systems that make up the infrastructure of our cities, and the complexities of interactions and interoperability among such complex systems, it is apparent that technology standards play an increasingly important role. The standards community recognizes this importance and continues to facilitate interdisciplinary dialog to deploy technology in wide-ranging services such as water, sanitation, power, police, and transportation. In this issue, Dr. Roger Lea takes us through an elaborate journey of various standards and standards development organizations (SDOs) and explains the need for strategic and process standards in addition to the technical specifications necessary to build and operate city-wide systems. Bill Ash and Sri Chandra provide IEEE's view of the smart city standards, especially the IoT architectural framework necessary for building flexible, expandable systems that adapt to future requirements. Dr. Anil Roy of DAIICT provides an extensive list of standards used by smart city planners ranging from connected vehicles and connected consumer devices to smart meters, smart grid, renewable energy, and safety. He also explains the need for measuring compliance with such standards. It is a very comprehensive survey that everyone interested in smart city technology should invest some time in.

With a plethora of current and upcoming standards applicable to smart cities, one may think this work is complete. This is where Dr. Fabio Duarte and Dr. Carlo Ratti, our researcher friends from the MIT Senseable City Lab, challenge us to think beyond what meets the eye. Smart city is not just a set of systems that connect buildings and infrastructure; it includes people, and it is supposed to serve their lifestyle. In the article, the authors put the people side into the consideration, which includes sensibility of applications and continuous improvements through big data analysis.

Of course, the questions remain—what is a smart city in your opinion, and is my smart city smarter than your smart city? What happens when not-so-smart people attempt to live in a smart city, get "trained" in the lifestyle, and then go to another smart city with a different lifestyle? We don't always have the opportunity to build new cities from scratch, so how do we incrementally make today's not-so-smart cities smarter without causing chaos? Will there be smart towns and villages or will smartness be a privilege for big cities because the infrastructure costs are too high for smaller communities? After all, SimCity may be just a game that you may abandon at any time, but smart city is where you live and work—no quitting here. That's why we need standards and education about standards for all smart city designers, developers, and administrators.
Be smart!
Yatin Trivedi

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Most recently, Yatin served as Director of Strategic Marketing at Synopsys. In 1992, Yatin co-founded Seva Technologies as one of the early Design Services companies in Silicon Valley. He co-authored the first book on Verilog HDL in 1990 and was the Editor of IEEE Std 1364-1995™ and IEEE Std 1364-2001™. He also started, managed and taught courses in VLSI Design Engineering curriculum at UC Santa Cruz extension (1990-2001). Yatin started his career at AMD and also worked at Sun Microsystems.

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Making Sense

of the Smart City Standardization Landscape

by Rodger Lea

Over recent years there has been a major worldwide push towards smart cities with many major world cities rolling out initiatives and new services aimed at improving cities and the lives of citizens. Partly driven by this rollout, international and national standards bodies have begun to identify and propose standards for activities and technologies associated with smart cities. However, because the breadth and range of activities under the smart city umbrella is so large–from smart city performance indicators to water pipes, from transportation to open data–the range and breadth of the standardization activities is equally as large and can be quite daunting. This short article aims to provide a high-level overview of some of the key standards groups and their smart city activities.

Categorizing Standardization Activities

The amount of activity in smart city standardization is truly broad and covers many areas. Some groups, such as IEEE, are looking at detailed technology aspects related to smart city networking or transportation while others, such as the International Organization for Standards (ISO), have a focus on higher-level activities such as strategies for smart city governance or procurement. A useful way to categorize these different types of standardization activities, and one promoted by the UK's British Standards Institute (BSI), is to group them by level of abstraction into strategic, process, and technical. (See the BSI's PD 8100 smart city overview for more details.)

Level 1: Strategic. These are smart city standards that aim to provide guidance to city leadership and other bodies on the "process of developing a clear and effective overall smart city strategy." They include guidance in identifying priorities, how to develop a roadmap for implementation, and how to effectively monitor and evaluate progress along the roadmap.

Level 2: Process. Standards in this category are focused on procuring and managing smart city projects–particularly those that cross both organizations and sectors. Essentially these offer best practices and associated guidelines.

Level 3: Technical. This level covers the myriad technical specifications that are needed to actually implement smart city products and services so that they meet the overall objectives

As the BSI states: "Strategic-level standards are of most relevance to city leadership and process-level standards to people in management posts. However, even technical specifications are relevant to people in management posts, as they need to know which standards they need to refer to when procuring technical products and services." (From BSI PD 8100)

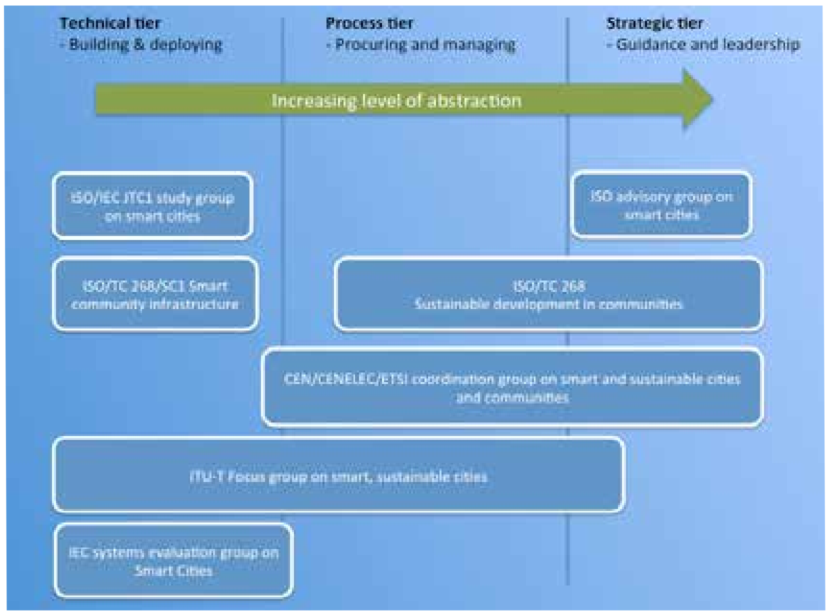
Using the Framework to Position and Group Standards Activities

Using this three-tier framework, it is possible to place many of the major international standards activities to better understand where their focus lies. The major international groups that have smart city activities include:

- ISO: International Organization for Standards is the main global body that national standards bodies work with and which many of us are familiar with via "ISO certified." ISO has set up a strategy advisory group (SAG) for smart cities which is helping coordinate ISO activities and has been instrumental in helping in the formation of Technical Committee 268, which is developing standards across all three tiers.
- CEN/CENELEC/ETSI: In Europe, standards are developed and agreed to by the three officially recognized European standardization organizations: the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI). These groups have set up a coordination group focused on smart and sustainable cities and communities.
- ITU: The International Telegraph Union is the United Nations' specialized agency for information and communication technologies– It created a focus group on smart sustainable cities (FG-SSC) that delivered a series of technical reports. A follow-on group, Study Group 20, is continuing that work.
- IEC: Founded in 1906, the IEC (International Electrotechnical Commission) is an established organization for the preparation and publication of international standards for all electrical, electronic, and related technologies, known

collectively as "electrotechnology." The IEC has a joint technical group with the ISO looking at smart cities, and its own system evaluation group on smart cities.

Fig. 1 places these groups graphically and identifies which subgroups are active in each of the three tiers.



Looking at the output from some of these groups, we can now identify ongoing activities or standards and place them into the appropriate categories

STRATEGIC–Aimed at the Process of Developing a Clear and Effective Overall Smart City Strategy

- **ISO 37120,** Sustainable Development of Communities–Indicators for city services and quality of life. This standard, part of a suite by ISO's Technical Committee 268 (TC 268), identifies 100 indicators that cities should track to allow them to benchmark progress. Actually, there are 17 areas, 46 core and 54 supporting indicators, that cities either "shall" (core) or "should" (supporting) track and report. The World Council on City Data has been set up by cities to benchmark cities, has certified 17 global cities, and is a good place to see this standard in use.
- Two draftISO standards, also from TC 268, but looking very much at management and strategy, are ISO 37101, Sustainable development and resilience of communities–Management systems–General principles and requirements; and ISO 37102, Sustainable development and resilience of communities– An overview of this ongoing project can be found on the ISO's website.
- Although not an international organization, the BSI's BS 8904 has a focus on sustainable communities and "provides a framework for recommendations and guidance that assist communities to improve. The recommendations and guidance are intended to be applied by communities of any size, structure, and type."

PROCESS: Procuring and Managing Smart City Projects

- The development by the BIS of a smart city framework standard (PAS 181) falls into the process category. "It provides practical, "how-to" advice, reflecting current good practice as identified by a broad range of public, private, and voluntary sector practitioners engaged in facilitating UK smart cities."
- Related to PAS 181 is the development of a data concept model for smart cities (PAS 182). This is an interesting activity, as a data model is critical for the development of smart city data hubs and data interoperability issues that are key components of any open data strategy.

TECHNICAL: Implementing Smart City Projects

- Two technical standards from the ISO/IEC JTC1 group that are still under development are: ISO/IEC AWI 30145, Information technology–Smart city ICT reference framework, and the associated ISO/IEC AWI 30146, Information technology–Smart city ICT indicators, which are both looking at the ICT infrastructure needed for smart cities.
- A useful overview of the technical activities of the ISO, IEC, and ITU can be found in a report from the ISO/IEC JTC1–Preliminary Report on Smart Cities. This document lays out the smart city space from a technical point of view with a good overview of the technical areas that the ISO, IEC, and ITU are working on, as well as details of their standards work and of the overall activities of JTC1.

IEEE Standards

IEEE has a wide variety of standards and ongoing activities that relate to key technical areas of the future smart city. Generally IEEE standards, due to their nature, fall under the category of technical standardization. One of the most critical is IEEE P2413, which is a developing standard for an architectural framework for the Internet of Things (IoT). The standard is being designed to offer a reference model defining relationships among various IoT verticals critical to smart cities, such as transportation and healthcare, and their common architectural elements.

In addition, IEEE has ongoing activities in areas such as:

Energy:
- **IEEE 1547** series on handling distributed resources in electric power systems
- **IEEE 1815** series on electric power systems communications
- **IEEE 2030** series on the smart grid, including electric vehicle infrastructure

Smart Transportation:
- **IEEE 1609** series on intelligent transportation
- **IEEE Std 2030.1.1-2015** IEEE Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles
- **IEEE 2040** series on connected, automated, and intelligent vehicles (IEEE pre-standards activities)

IEEE also has ongoing activities in smart buildings, security, and communications that are all relevant to smart cities.

A more complete list of IEEE activities involving the smart city can be found in the regularly-updated report IEEE Standards Activities for Smart Cities. In addition, IEEE maintains a smart city community website to help coordinate member activities in the smart city area, which provides regular updates on activities and conferences related to smart cities.

Conclusion

The 21st century is one of rapid urbanization. Ensuring that the world's cities offer citizens a rich and rewarding lifestyle requires that cities exploit technology to enrich people's lives, deliver services, and ensure sustainable growth. The breadth and scope of this task touches on many areas, and requires a holistic approach that not only looks at core technical issues, but also needs to consider the management, process, and strategies associated with smart cities. As always, standards play a key role in facilitating the adoption of new technologies and are critical to the growth of smart cities worldwide.

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Currently CEO of an Internet of Things (IoT) startup, Sense Tecnic Systems Inc., Dr. Lea has over 25 years of experience spanning academia, large corporations, and startups. For the last 10 years, he has started or helped start four new companies while managing an active research program (University of British Columbia, Canada, and Lancaster University, UK) into distributed and ubiquitous computing. Prior to his being involved with startups, Dr. Lea spent over 15 years in industrial research, most recently as Vice President and Director of Sony's Distributed System Laboratory, located in Silicon Valley, CA.

Standards and the Smart City

by Bill Ash and Srikanth Chandrasekaran

Undergirding all of the promising services that figure to play prominently in tomorrow's sustainable "smart" cities—new economic and governance models, improvements in personal health and public safety, advanced capabilities for traffic, waste, and water management, etc.—will be foundational information and communications technologies (ICT) and networking capabilities that are rapidly emerging around the world today. And undergirding augmented reality, cloud computing, e-health, the Internet of Things (IoT), smart grid, and other innovative capabilities are foundational technology standards.

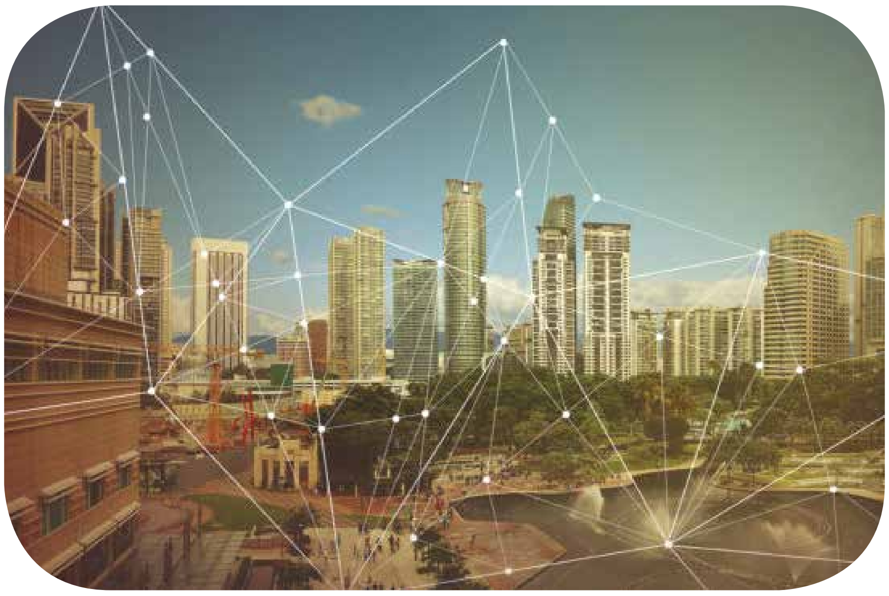
Standards play a crucial role in the success and efficiency of solution deployment by providing industry with a lower-cost platform for ongoing innovation and expanding market growth and consumer choice. Not only do standards effectively give manufacturers a blueprint on which to build their products, they also provide greater assurance of a sufficient market for those products.

For smart cities, crucial, consensus-based standards are being created and refined through globally-open collaboration across traditional geographic, industrial, and technological boundaries. How is standards innovation helping bring about the quality-of-life and sustainability advances that are envisioned for the world's city dwellers?

The Infrastructure of Sustainability

Open standards are instrumental to ongoing innovation and global market growth in technology development that will have a long-term impact on tomorrow's sustainable cities. In the decades to come, standards will create a foundation of interoperability upon which next-generation technologies and capabilities can be cost-effectively and seamlessly layered.

It was this thinking that led to the launch of the globally-open development effort to create IEEE P2413, Draft IEEE Standard for an Architectural Framework for the Internet of Things (IoT). This standard-development project was initiated in light of insights gleaned from cross-disciplinary workshops and roundtables that the IEEE Standards Association (IEEE-SA) held with global IoT leaders.



IEEEP2413(http://standards.ieee.org/develop/project/2413.html) is in development to propose an architectural framework supporting cross-domain interaction, system interoperability and functional compatibility, and to fuel the growth of the IoT market. The standard is being designed to offer a reference model defining relationships among various IoT verticals such as transportation and healthcare (the same verticals that are being transformed in the world's transition to smart cities) and their common architectural elements.

The IEEE-SA is known for taking a system-of-systems perspective in standardization. IEEE 2030, IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads, is another example of the type of overarching effort that is being undertaken in the development of IEEE P2413. The IEEE 2030 development effort integrated wide-ranging expertise from the world's power, energy, information technology, and communications spaces. Such coordination and scope are required for the development of foundational standards for environments such as the IoT and smart cities, in which new technologies and legacy must work together to enable new capabilities and applications.

Of course, many of the standards that tomorrow's sustainable cities will require already exist. Beyond IEEE P2413 and IEEE 2030, the IEEE-SA's portfolio of standards and standards in development already include many of prime relevance to this space, such as IEEE 802.3, IEEE Standard for Ethernet, and IEEE 802.11 [1], which enables products that are often branded as "Wi-Fi" in the market. But additional standards development will be required in far-ranging areas including augmented reality, cloud computing, e-health, the IoT, and the smart grid.

Facilitating Collaborative Innovation

It won't happen magically. The challenges of bringing about globally-relevant standards for tomorrow's smart cities are substantial, including enabling seamless technology and application integration; taking into proper account varying regional, governmental, and regulatory priorities; and fueling consumer confidence.

Global, open standards development rooted in inclusivity and due process provides a balanced, multi-stakeholder environment for working together to forge solutions and advance innovation for tomorrow's smart cities. The IEEE standards-development process is noted for such characteristics and adheres to the standardization principles stated by the World Trade Organization (WTO), including openness, consensus, balance, right of appeal, and due process. Thousands and thousands of individuals—from startups to well-established companies around the world, companies that in many cases are competitors of one another—have contributed to the open development of IEEE standards.

IEEE provides a proven, democratic platform for globally-open collaboration for the benefit of humanity—not only in the creation of standards, but throughout the whole lifecycle of technology innovation.

IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity, with about a half million members in over 160 countries. IEEE annually hosts more than 1,400 conferences across multiple technology disciplines, and IEEE Xplore is home to over 4 million technical documents that are available to engineers worldwide. Technologists around the world tap into unmatched access to cross-disciplinary expertise through IEEE.

The IEEE Future Directions Committee is focused on new and emerging technologies and world challenges specifically, and coordinates IEEE technical resources around the world. Initiatives have been created around key, rapidly developing areas of innovation, including big data, cybersecurity, green ICT, rebooting computing, smart cities, software defined networks, and smart materials. IEEE Smart Cities (http://smartcities.ieee.org), for example, was launched to provide a global, multidisciplinary forum through which the world's cities can share their unique lessons learned and best practices as they undertake technological and behavioral innovation across diverse areas such as energy, food and water, public health and safety, communications, etc.

The IEEE Smart Cities initiative is also working closely with the municipalities and government bodies of the selected smart cities to build awareness. As part of the education focus, two massive open online courses (MOOCs) have been developed on the Edx platform: Big Data for Smart Cities and Introduction to Metrics for Smart Cities.

Conclusion

IEEE technologists are dedicated to advancing technological innovation and excellence for the benefit of humanity, and they cover augmented reality, cloud computing, e-health, the IoT, smart grid, and other technologies that will have a role in tomorrow's smart cities. But IEEE isn't just helping facilitate development of standards and technology for smart cities. Through standardization and other globally-open collaborative activities, IEEE is staying engaged with stakeholders of diverse technology areas and geographic markets around the globe as cities evolve over the long-term to achieve sustainability and advances in quality-of-life for their inhabitants.

Learn more about IEEE standards and the important role they play in the advancement of technology through IEEE Standards University. View IEEE's educational offerings regarding smart cities through the IEEE Smart Cities website.

References

[1] IEEE 802.11, IEEE Standard for Information Technology–Telecommunications and information exchange between systems, Local and metropolitan area networks–Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

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Smart City:
Do We Have Enough Standards?

by Mark Halverson and Leanne Seeto

A survey document on the industry connections activity initiation document (ICAID) of the IEEE Gujarat Section

Gone are the days of smart devices. Here comes the age of smart cities. In layman's terms, smart cities are driven by intelligent sensors, machine-to-machine connections, and efficient and secured decision support systems that all ultimately result in increased productivity and a happy life.

So, what is the way forward if we want to implement the beautiful concept of a smart city into our city? It is too complex, too connected, and dependent upon so many other services, applications, and platforms. It deals with huge data. Its decision support systems should be as dynamic as possible. Resources have to be planned in the most optimized form. And above all, it has to ensure the safety and security of citizens and their data. In this highly entangled environment, where it is too difficult to think of a single centralized control room, all technology platforms should have interoperability such that applications can move from one platform to another seamlessly. This necessitates the availability of industrial standards. There are standards in each and every domain, but do we have standards across all domains? That is the biggest challenge in front of technology drivers. Industrial standards for sensors, and ultimately standards for the smart city, need to evolve.

IEEE standards that are available and have direct relevance to the application segments and verticals of a smart city are presented in the following table.[1] However, other applicable standards may exist.

SEGMENT & IEEE STANDARDS WITH DESCRIPTIONS

1. Connected Vehicles
Transport Electrification

1547 Series	Standard for Interconnecting Distributed Resources with Electric Power Systems
1901 Series	A standard for high-speed communication devices via electric power lines, so-called broadband over power line (BPL) devices, is defined
2030 Series	This series provides alternative approaches and best practices for achieving smart grid interoperability
P1562	Guide for Array and Battery Sizing in Stand-Alone Photovoltaic (PV) Systems

Intelligent Transport System

802.11	IEEE Standard for Information Technology–Telecommunications and information exchange between systems–Local and metropolitan area networks: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications
1616	A performance standard for MVEDR data collection, storage, and retrieval, to ensure that comparable event data parameters are generated by all vehicles, is described

Connectivity

802.2	IEEE Standard for Local and Metropolitan Area Networks–Media Independent Handover Services
802.22	Standard for wireless regional area network (WRAN) using white spaces in the television (TV) frequency spectrum
802.3	IEEE Standard for Ethernet

802.15 Series	A working group of the Institute of Electrical and Electronics Engineers (IEEE), the IEEE 802 standards committee specifies wireless personal area network (WPAN) standards; includes seven task groups

Vehicular Network

1609	IEEE Guide for Wireless Access in Vehicular Environments (WAVE)–Architecture
1609.1	Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE)–Resource Manager
1609.11	IEEE Standard for Wireless Access in Vehicular Environments (WAVE)–Over-the-Air Electronic Payment Data Exchange Protocol for Intelligent Transportation Systems (ITS)
1609.12	IEEE Standard for Wireless Access in Vehicular Environments (WAVE)–Identifier Allocations
1609.2	IEEE Standard for Wireless Access in Vehicular Environments–Security Services for Applications and Management Messages
1609.3	IEEE Standard for Wireless Access in Vehicular Environments (WAVE)–Networking Services
1609.4	IEEE Standard for Wireless Access in Vehicular Environments (WAVE)–Multi-Channel Operation

Smart Rail

11-2000	IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles
16-2004	IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles
1473	IEEE Standard for Communications Protocol aboard Passenger Trains
1474	Communications Based Train Control (CBTC)
1475	IEEE Standard for the Functioning of Interfaces among Propulsion, Friction Brake, and Rain-Borne Master Control on Rail Rapid Transit Vehicles
1476	IEEE Standard for Passenger Train Auxiliary Power Systems Interfaces
1477	IEEE Standard for Passenger Information System for Rail Transit Vehicles
1482.1	IEEE Standard for Rail Transit Vehicle Event Recorders
1483	IEEE Standard for Verification of Vital Functions in Processor-Based Systems Used in Rail Transit Control

2. Consumer Connectivity

Smart Grid into Home Devices

1675	IEEE Standard for Broadband over Power Line Hardware
1775	IEEE Standard for Power Line Communication Equipment–Electromagnetic Compatibility (EMC) Requirements–Testing and Measurement Methods
1901	IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications
1901.2	IEEE Standard for Low-Frequency (less than 500 kHz) Narrowband Power Line Communications for Smart Grid Applications
2030	IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads

Home Networking Standard

1815	IEEE Standard for Electric Power Systems Communications–Distributed Network Protocol (DNP3)
1905.1	IEEE Standard for a Convergent Digital Home Network for Heterogeneous Technologies
1901 Series	A standard for high-speed communication devices via electric power lines, so-called broadband over power line (BPL) devices, is defined
802 Series	IEEE 802 refers to a family of IEEE standards dealing with local area networks and metropolitan area networks
P1901.2	This standard specifies communications for low frequency (less than 500 kHz) narrowband power line devices via alternating current and direct current electric power lines. This standard supports indoor and outdoor communications over low voltage lines (lines between transformer and meter, less than 1000 V), through a transformer low-voltage to medium-voltage (1000 V up to 72 kV), and through transformer medium-voltage to low-voltage power lines in both urban and in long distance (multi-kilometer) rural communications.

3D Video Standards

P3333.1	IEEE Approved Draft Standard for the Quality of Experience (QoE) and Visual Comfort Assessments of Three Dimensional (3D) Contents Based on Psychophysical Studies

Mobile Video Standards

802.11	IEEE Standard for Information Technology–Telecommunications and information exchange between systems–Local and metropolitan area networks: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications
2200	IEEE Standard Protocol for Stream Management in Media Client Devices
P1858	Standard for Camera Phone Image Quality (CPIQ)
P1907.1	Standard for Network-Adaptive Quality of Experience (QoE) Management Scheme for Real-Time Mobile Video Communications

3. Green Technology
Green Community Network

1888	IEEE Standard for Ubiquitous Green Community Control Network Protocol
P1888.1	Standard for a Ubiquitous Community Network: Control and Management
P1888.2	Standard for Ubiquitous Green Community Control Network: Heterogeneous Networks Convergence and Scalability
P1888.3	Standard for Ubiquitous Green Community Control Network: Security
P1888.4	Green Smart Home and Residential Quarter Control Network Protocol

Environment Product Assessment

1680	IEEE Standard for Environmental Assessment of Electronic Products
1680.1	IEEE Standard for Environmental Assessment of Personal Computer Products, Including Notebook Personal Computers, Desktop Personal Computers, and Personal Computer Displays
1680.2	IEEE Standard for Environmental Assessment of Imaging Equipment
1680.3	IEEE Standard for Environmental Assessment of Televisions

Smart Metering

1377	IEEE Standard for Utility Industry Metering Communication Protocol Application Layer (End Device Data Tables)
1701	IEEE Standard for Optical Port Communication Protocol to Complement the Utility Industry End Device Data Tables
1703	IEEE Standard for Local Area Network/Wide Area Network (LAN/WAN) Node Communication Protocol to Complement the Utility Industry End Device Data Tables
P1704	IEEE Recommended Practice for the Instrumentation and Metering of Industrial and Commercial Power Systems
P1705	Standard for Utility Industry End Device Communications Module
P3005.7	Standard for Compliance Testing Standard for Utility Industry Metering Communications Protocol Standards
3001.8	Recommended Practice for the Application of Metering for Energy Management of Industrial and Commercial Power Systems

Smart Grid

1547 Series	Standard for Interconnecting Distributed Resources with Electric Power Systems
1901 Series	A standard for high-speed communication devices via electric power lines, so-called broadband over power line (BPL) devices, is defined
P1901.2	IEEE Standard for Low-Frequency (less than 500 kHz) Narrowband Power Line Communications for Smart Grid Applications
P1901.2	This series provides alternative approaches and best practices for achieving smart grid interoperability

Energy Efficient Communications Networking

802.1	IEEE Standard for Local and Metropolitan Area Networks
802.11	IEEE Standard for Information Technology–Telecommunications and information exchange between systems–Local and metropolitan area networks: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications
802.16	Broadband Wireless MANs
802.22	A standard for wireless regional area networks (WRANs) using white spaces in the television (TV) frequency spectrum
802.3	IEEE Standard for Ethernet
802.15.4	IEEE Standard for Local and Metropolitan Area Networks–Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)
1815 Series	IEEE Standard for Electric Power Systems Communications–Distributed Network Protocol (DNP3)

1901	IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications
P1904.1	Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPONs)

Renewable Energy Generation

937	IEEE Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for Photovoltaic (PV) Systems
1013	IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stand-Alone Photovoltaic (PV) Systems
1361	IEEE Guide for Selection, Charging, Test, and Evaluation of Lead-Acid Batteries Used in Stand-Alone Photovoltaic (PV) Systems
1526	IEEE Recommended Practice for Testing the Performance of Stand-Alone Photovoltaic Systems
1561	IEEE Guide for Optimizing the Performance and Life of Lead-Acid Batteries in Remote Hybrid Power Systems
1562	IEEE Guide for Array and Battery Sizing in Stand-Alone Photovoltaic (PV) Systems
1661	IEEE Guide for Test and Evaluation of Lead-Acid Batteries Used in Photovoltaic (PV) Hybrid Power Systems
P1595	Standard for Designating and Quantifying Green Energy Projects in the Electricity Sector
P1797	Guide for Design and Application of Solar Technology in Commercial Power Generating Stations
PC57.159	IEEE Draft Guide on Transformers for Application in Distributed Photovoltaic (DPV) Power Generation Systems

Energy Efficiency

1621	IEEE Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments
1801	IEEE Standard for Design and Verification of Low-Power Integrated Circuits
P1823	IEEE Standard for Universal Power Adapter for Mobile Devices
P1889	Guide for Evaluating and Testing the Electrical Performance of Energy Saving Devices
P2030.5	Standard for Smart Energy Profile Application Protocol

Safety from Hazardous Radiation

C95.1	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
C95.1-2345	IEEE Standard for Military Workplaces–Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz
C95.2	IEEE Standard for Radio-Frequency Energy and Current-Flow Symbols
C95.3	American National Standard Techniques and Instrumentation for the Measurement of Potentially Hazardous Electromagnetic Radiation at Microwave Frequencies

C95.3	IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz to 300 GHz
C95.3.1	IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 100 kHz
C95.4	IEEE Recommended Practice for Determining Safe Distances From Radio Frequency Transmitting Antennas When Using Electric Blasting Caps During Explosive Operations
C95.5	American National Standard Recommended Practice for the Measurement of Hazardous Electromagnetic Fields–RF and Microwave
C95.6	IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz
C95.7	IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz

The IEEE Standards Association (IEEE-SA) should form focus groups to study and report if these standards allow interoperability. If not, respective working groups are to be formed that will work on protocols to ensure the interoperability of these standards.

Besides IEEE, there are many organizations that have been developing standards in one or many of the verticals pertaining to a smart city, e.g., AIM (Association for Automatic Identification and Mobility); ASCE (American Society of Civil Engineers); BIS (Bureau of Indian Standards); BSI (British Standards Institution); CITS (Collaboration on ITS Communication Standards); ETSI (European Telecommunications Standards Institute); IETF (Internet Engineering Task Force); IEC (International Electrotechnical Commission); ISO (International Organization for Standardization); ITU (International Telecommunication Union); ITU-T (International Telecommunication Union Standardization Sector); NIST (National Institute of Standards and Technology); OGC (Open Geospatial Consortium); SAC (Standardization Administration of the People's Republic of China); SDO (Standards Development Organization); SEG (Systems Evaluation Group); SIGGRAPH (Special Interest Group for Computer GRAPHics); UNFCCC (United Nations Framework Convention on Climate Change); and the W3C (World Wide Web Consortium).

The ITU has set up the "Focus Group on Smart Sustainable Cities."[1] This group has published over twenty technical reports on different topics belonging to the overall smart city domain, along with its "Standardization Roadmap for Smart Sustainable Cities."[2] These are valuable reports to give all stakeholders a deep insight into the concept of a smart city before they decide to turn the concept into reality. Otherwise, the project of building a smart city may become another mere city with some automation and fancy sensor-based applications. Some of them, for reference, are:

1. Standardization roadmap for smart sustainable cities,
2. Technical report–city leaders guide,
3. Technical report–KPIs definitions,
4. Technical report–masterplan framework,
5. Technical report–smart water management in cities,
6. Technical report–SSC architecture,
7. Technical report–ICTs for climate change adaptation,
8. Technical report–multiservice infrastructure for SSC in new development areas,
9. Technical report–smart buildings,
10. Technical report–EMF,
11. Technical report–anonymization infrastructure open data in SSC,
12. Technical report–integrated management for SSC,
13. Technical report–ICT infrastructure for resilience security,
14. Technical report–smart sustainable cities infrastructure,
15. Technical report–standardization roadmap,
16. Technical report–standardization activities.

On the other hand, the ISO has developed the following standards, which may be useful while working on any or many verticals of a smart city:

ISO 10711:2012	Intelligent transport systems–Interface protocol and message set definition between traffic signal controllers and detectors
ISO/TR 10992.2011	Intelligent transport systems–Use of nomadic and portable devices to support ITS service and multimedia provision in vehicles
ISO 11067	Intelligent transport systems–Curve speed warning systems (CSWS)–Performance requirements and test procedures

ISO 11270:2014	Intelligent transport systems–Lane keeping assistance systems (LKAS)– Performance requirements and test procedures
ISO/TR 11766:2010	Intelligent transport systems–Communications access for land mobiles (CALM)–Security considerations for lawful interception
ISO/TR 11769:2010	Intelligent transport systems–Communications access for land mobiles (CALM)–Data retention for law enforcement
ISO/TS 12813:2009	Electronic fee collection–Compliance check communication for autonomous systems
ISO 12855:2012	Electronic fee collection–information exchange between service provision and toll charging
ISO/TR 12859:2009	Intelligent transport systems–System architecture–Privacy aspects in ITS standards and system
ISO/TS 13140-1:2011	Electronic fee collection–Evaluation of on-board and roadside equipment for conformity to ISO/TS 13141–Part 1: Test suite structure and test purposes
ISO/TS 13140-2:2012	Electronic fee collection–Evaluation of on-board and roadside equipment for conformity to ISO/TS 13141–Part 2: Abstract test suite
ISO/TS 13141:2010	Electronic fee collection–Localization augmentation communication for autonomous systems
ISO/TS 13143-1:2011 Parts 1 & 2	Electronic fee collection–Evaluation of on-board and roadside equipment for conformity to ISO/TS 12813–Part 1: Test suite structure and test purposes
ISO 13183:2012	Intelligent transport systems–Communications access for land mobiles (CALM)–Using broadcast communications
ISO/TR 13184-1:2013	Intelligent transport systems–Guidance protocol via personal ITS station for advisory safety systems–Part 1: General information and use case definitions
ISO/TR 13185-1:2012	Intelligent transport systems–Vehicle interface for provisioning and support of ITS services–Part 1: General information and use case definition
ISO/TR 14806:2013	Intelligent transport systems–Public transport requirements for the use of payment applications for fare media
ISO 14813-1:2007	Intelligent transport systems–Reference model architecture(s) for the ITS sector–Part 1: ITS service domains, service groups, and services
ISO 14813-5:2010	Intelligent transport systems–Reference model architecture(s) for the ITS sector–Part 5: Requirements for architecture description in ITS standards
ISO 14813-6:2009	Intelligent transport systems–Reference model architecture(s) for the ITS sector–Part 6: Data presentation in ASN.1
ISO 14814:2006	Road transport and traffic telematics–Automatic vehicle and equipment identification–Reference architecture and terminology
ISO 14815:2005	Road transport and traffic telematics–Automatic vehicle and equipment identification–System specifications
ISO 14816:2005	Road transport and traffic telematics–Automatic vehicle and equipment identification–Numbering and data structure

ISO 14817:2002	Transport information and control systems–Requirements for an ITS/TICS central data registry and ITS/TICS data dictionaries
ISO 14819-1:2013	Intelligent transport systems–Traffic and travel information messages via traffic message coding–Part 1: Coding protocol for radio data system–Traffic message channel (RDS-TMC) using ALERT-C
ISO 14819-2:2013	Intelligent transport systems–Traffic and travel information messages via traffic message coding–Part 2: Event and information codes for radio data system–traffic message channel (RDS-TMC) using ALERT-C
ISO 14819-3:2013	Intelligent transport systems–Traffic and travel information messages via traffic message coding–Part 3: Location referencing for radio data system–Traffic message channel (RDS-TMC) using ALERT-C
ISO 14819-6:2006	Traffic and Traveler Information (TTI)–TTI messages via traffic message coding –Part 6: Encryption and conditional access for the radio data system–Traffic message channel ALERT C coding
ISO/TS 14823:2008	Traffic and travel information–Messages via media independent stationary dissemination systems–Graphic data dictionary for pre-trip and in-trip information dissemination systems
ISO 14825:2011	Intelligent transport systems–Geographic data files (GDF)–GDF5.0
ISO 14827-1:2005	Transport information and control systems–Data interfaces between centers for transport information and control systems–Part 1: Message definition requirements
ISO 14827-2:2005	Transport information and control systems–Data interfaces between centers for transport information and control systems–Part 2: DATEX-ASN
ISO/TS 14904:2002	Road transport and traffic telematics–Electronic fee collection (EFC)–Interface specification for clearing between operators
ISO 14906:2011	Electronic fee collection–Application interface definition for dedicated short-range communication
ISO/TS 14907-1:2010	Electronic fee collection–Test procedures for user and fixed equipment–Part 1: Description of test procedures
ISO/TS 14907-2:2011	Electronic fee collection–Test procedures for user and fixed equipment–Part 2: Conformance test for the onboard unit application interface
ISO 15075:2003	Transport information and control systems–In-vehicle navigation systems–Communications message set requirements
ISO 15622:2010	Intelligent transport systems–Adaptive cruise control systems–Performance requirements and test procedures
ISO 15623:2013	Intelligent transport systems–Forward vehicle collision warning system– Performance requirements and test procedures
ISO/TS 15624:2001	Transport information and control systems–Traffic impediment warning systems (TIWS)–System requirements
ISO 15628:2013	Intelligent transport systems –Dedicated short range communication (DSRC)–DSRC application layer

ISO 15638-1:2012	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 1: Framework and architecture
ISO 15638-2:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 2: Common platform parameters using CALM
ISO 15638-3:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 3: Operating requirements, "Approval authority" procedures and enforcement provisions for the providers of regulated services
ISO 15638-5:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 5: Generic vehicle information
ISO 15638-6:2014	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 6: Regulated applications
ISO 15638-7:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 7: Other applications
ISO 15638-8:2014	Intelligent transport systems–Framework for cooperative telematics applications for regulated vehicles (TARV)–Part 8: Vehicle access management
ISO/TS 15638-9:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 9: Remote electronic tachograph monitoring (RTM)
ISO/TS 15638-10:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 10: Emergency messaging system/ eCall (EMS)
ISO 15638-11:2014	Intelligent transport systems–Framework for cooperative telematics applications for regulated vehicles (TARV)–Part 11: Driver work records
ISO 15638-12:2014	Intelligent transport systems–Framework for cooperative telematics applications for regulated vehicles (TARV)–Part 12: Vehicle mass monitoring
ISO 15638-14:2014	Intelligent transport systems–Framework for cooperative telematics applications for regulated vehicles (TARV)–Part 14: Vehicle access control
ISO 15638-15:2014	Intelligent transport systems–Framework for cooperative telematics applications for regulated vehicles (TARV)–Part 15: Vehicle location monitoring
ISO 15638-16:2014	Intelligent transport systems–Framework for cooperative telematics applications for regulated vehicles (TARV)–Part 16: Vehicle speed monitoring
ISO 15638-17:2014	Intelligent transport systems–Framework for cooperative telematics applications for regulated vehicles (TARV)–Part 17: Consignment and location monitoring

ISO/TS 15638-18:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 18: ADR (dangerous goods) transport monitoring (ADR)
ISO/TS 15638-19:2013	Intelligent transport systems–Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV)–Part 19: Vehicle parking facilities (VPF)
ISO 15662:2006	Intelligent transport systems–Wide area communication–Protocol management information
ISO 15784-1:2008	Intelligent transport systems (ITS)–Data exchange involving roadside modules communication–Part 1: General principles and documentation framework of application profiles
ISO 15784-3:2008	Intelligent transport systems (ITS)–Data exchange involving roadside modules communication–Part 3: Application profile-data exchange (AP-DATEX)
ISO/TS 16401-1:2012	Electronic fee collection–Evaluation of equipment for conformity to ISO/TS 17575-2–Part 1: Test suite structure and test purposes
ISO/TS 16401-2:2012	Electronic fee collection–Evaluation of equipment for conformity to ISO/TS 17575-2–Part 2: Abstract test suite
ISO/TS 16403-1:2012	Electronic fee collection–Evaluation of equipment for conformity to ISO/TS 17575-4–Part 1: Test suite structure and test purposes
ISO/TS 16403-2:2012	Electronic fee collection–Evaluation of equipment for conformity to ISO/TS 17575-4–Part 2: Abstract test suite
ISO/TS 16407-1:2011	Electronic fee collection–Evaluation of equipment for conformity to ISO/TS 17575-1–Part 1: Test suite structure and test purposes
ISO/TS 16407-2:2012	Electronic fee collection–Evaluation of equipment for conformity to ISO/TS 17575-1–Part 2: Abstract test suite
ISO/TS 16410-1:2011	Electronic fee collection – Evaluation of equipment for conformity to ISO/TS 17575-3 –Part 1: Test suite structure and test purposes
ISO/TS 16410-2:2012	Electronic fee collection–Evaluation of equipment for conformity to ISO/TS 17575-3–Part 2: Abstract test suite
ISO/TS 16785:2014	Electronic fee collection (EFC)–Interface definition between DSRC-OBE and external in-vehicle devices
ISO 17185-1:2014	Intelligent transport systems–Public transport user information–Part 1: Standards framework for public information systems
ISO/TS 17187:2013	Intelligent transport systems–Electronic information exchange to facilitate the movement of freight and its intermodal transfer–Governance rules to sustain electronic information exchange methods
ISO 17261:2012	Intelligent transport systems–Automatic vehicle and equipment identification–Intermodal goods transport architecture and terminology
ISO 17262:2012	Intelligent transport systems–Automatic vehicle and equipment identification–Numbering and data structures
ISO 17263:2012	Intelligent transport systems–Automatic vehicle and equipment identification–System parameters

ISO 17264:2009	Intelligent transport systems–Automatic vehicle and equipment identification–Interfaces
ISO 17267:2009	Intelligent transport systems–Navigation systems–Application programming interface (API)
ISO 17361:2007	Intelligent transport systems–Lane departure warning systems–Performance requirements and test procedures
ISO/TR 17384:2008	Intelligent transport systems–Interactive centrally determined route guidance (CDRG)–Air interface message set, contents, and format
ISO 17386:2010	Transport information and control systems–Maneuvering aids for low speed operation (MALSO)–Performance requirements and test procedures
ISO 17387:2008	Intelligent transport systems–Lane change decision aid systems (LCDAS)– Performance requirements and test procedures
ISO/TS 17419:2014	Intelligent transport systems–Cooperative systems–Classification and management of ITS applications in a global context
ISO/TS 17423:2014	Intelligent transport systems–Cooperative systems–ITS application requirements and objectives for selection of communication profiles
ISO/TS 17427:2014	Intelligent transport systems–Cooperative systems–Roles and responsibilities in the context of cooperative ITS based on architecture(s) for cooperative systems
ISO/TS 17444-1:2012	Electronic fee collection–Charging performance–Part 1: Metrics
ISO/TS 17444-2:2013	Electronic fee collection–Charging performance–Part 2: Examination framework
ISO/TR 17452:2007	Intelligent transport systems–Using UML for defining and documenting ITS/TICS interfaces
ISO/TR 17465-1:2014	Intelligent transport systems–Cooperative ITS–Part 1: Terms and definitions
ISO 17572-1:2015	Intelligent transport systems (ITS)–Location referencing for geographic databases–Part 1: General requirements and conceptual model
ISO 17572-2:2015	Intelligent transport systems (ITS)–Location referencing for geographic databases–Part 2: Pre-coded location references (pre-coded profile)
ISO 17572-3:2015	Intelligent transport systems (ITS)–Location referencing for geographic databases–Part 3: Dynamic location references (dynamic profile)
ISO 17573:2010	Electronic fee collection–Systems architecture for vehicle-related tolling
ISO/TS 17574:2009	Electronic fee collection–Guidelines for security protection profiles
ISO/TS 17575-1:2010	Electronic fee collection–Application interface definition for autonomous systems–Part 1: Charging
ISO/TS 17575-2:2010	Electronic fee collection–Application interface definition for autonomous systems–Part 2: Communication and connection to the lower layers
ISO/TS 17575-3:2011	Electronic fee collection–Application interface definition for autonomous systems–Part 3: Context data

ISO/TS 17575-4:2011	Electronic fee collection–Application interface definition for autonomous systems–Part 4: Roaming
ISO/PAS 17684:2003	Transport information and control systems–In-vehicle navigation systems–ITS message set translator to ASN.1 format definitions
ISO 17687:2007	Transport information and control systems (TICS)–General fleet management and commercial freight operations–Data dictionary and message sets for electronic identification and monitoring of hazardous materials/dangerous goods transportation
ISO/TS 17931:2013	Intelligent transport systems–Extension of map database specifications for local dynamic map for applications of cooperative ITS
ISO/TS 18234-1:2013	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 1: Introduction, numbering, and versions (TPEG1-INV)
ISO/TS 18234-2:2013	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 2: Syntax, semantics, and framing structure (TPEG1-SSF)
ISO/TS 18234-3:2013	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 3: Service and network information (TPEG1-SNI)
ISO/TS 18234-4:2006	Traffic and travel information (TTI)–TTI via transport protocol expert group (TPEG) data-streams–Part 4: Road traffic message (RTM) application
ISO/TS 18234-5:2006	Traffic and travel information (TTI)–TTI via transport protocol expert group (TPEG) data-streams–Part 5: Public transport information (PTI) application
ISO/TS 18234-6:2006	Traffic and travel information (TTI)–TTI via transport protocol expert group (TPEG) data-streams–Part 6: Location referencing applications
ISO/TS 18234-7:2013	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 7: Parking information (TPEG1-PKI)
ISO/TS 18234-8:2012	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 8: Congestion and travel time application (TPEG1-CTT)
ISO/TS 18234-9:2013	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 9: Traffic event compact (TPEG1-TEC)
ISO/TS 18234-10:2013	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 10: Conditional access information (TPEG1-CAI)
ISO/TS 18234-11:2013	Intelligent transport systems–Traffic and travel Information (TTI) via transport protocol experts group, generation 1 (TPEG1) binary data format–Part 11: Location referencing container (TPEG1-LRC)

ISO/TS 20452:2007	Requirements and logical data model for a physical storage format (PSF) and an application program interface (API) and logical data organization for PSF used in intelligent transport systems (ITS) database technology
ISO 21210:2012	Intelligent transport systems–Communications access for land mobiles (CALM)–IPv6 Networking
ISO 21212:2008	Intelligent transport systems–Communications access for land mobiles (CALM)–2G Cellular systems
ISO 21213:2008	Intelligent transport systems–Communications access for land mobiles (CALM)–3G Cellular systems
ISO 21214:2006	Intelligent transport systems–Communications access for land mobiles (CALM)–Infra-red systems
ISO 21215:2010	Intelligent transport systems–Communications access for land mobiles (CALM)–M5
ISO 21216:2012	Intelligent transport systems–Communication access for land mobiles (CALM)–Millimeter wave air interface
ISO 21217:2014	Intelligent transport systems–Communications access for land mobiles (CALM)–Architecture
ISO 21218:2013	Intelligent transport systems–Communications access for land mobiles (CALM)–Access technology support
ISO/TS 21219-2:2014	Intelligent transport systems–Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2)–Part 2: UML modelling rules
ISO/TS 21219-3:2015	Intelligent transport system–Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2)–Part 3: UML to binary conversion rules
ISO/TS 21219-4:2015	Intelligent transport systems–Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2)–Part 4: UML to XML conversion rules
ISO/TS 21219-5:2015	Intelligent transport systems–Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2)–Part 5: Service framework (TPEG2-SFW)
ISO/TS 21219-6:2015	Intelligent transport systems–Traffic and travel information via transport protocol experts group, generation 2(TPEG2) –Part 6: Message management container (TPEG2-MMC)
ISO/TS 21219-18:2015	Intelligent transport systems–Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2)–Part 18: Traffic flow and prediction application (TPEG2-TFP)
ISO/TR 21707:2008	Intelligent transport systems–Integrated transport information, management, and control–Data quality in ITS systems
ISO 22178:2009	Intelligent transport systems–Low speed following (LSF) systems–Performance requirements and test procedures
ISO 22179:2009	Intelligent transport systems–Full speed range adaptive cruise control (FSRA) systems–Performance requirements and test procedures
ISO 22837:2009	Vehicle probe data for wide area communications

ISO 22839:2013	Intelligent transport systems–Forward vehicle collision mitigation systems–Operation, performance, and verification requirements
ISO 22840:2010	Intelligent transport systems–Devices to aid reverse maneuvers–Extended-range backing aid systems (ERBA)
ISO 22951:2009	Data dictionary and message sets for preemption and prioritization signal systems for emergency and public transport vehicles (PRESTO)
ISO 24014-1:2007	Public transport–Interoperable fare management system–Part 1: Architecture
ISO/TR 24014-2:2013	Public transport–Interoperable fare management system–Part 2: Business practices
ISO/TR 24014-3:2013	Public transport–Interoperable fare management system–Part 3: Complementary concepts to part 1 for multi-application media
ISO 24097-1:2009	Intelligent transport systems–Using web services (machine-machine delivery) for ITS service delivery–Part 1: Realization of interoperable web services
ISO/TR 24098:2007	Intelligent transport systems–System architecture, taxonomy, and terminology–Procedures for developing ITS deployment plans utilizing ITS system architecture
ISO 24099:2011	Navigation data delivery structures and protocols
ISO 24100:2010	Intelligent transport systems–Basic principles for personal data protection in probe vehicle information services
ISO 24101-1:2008	Intelligent transport systems–Communications access for land mobiles (CALM)–Application management–Part 1: General requirements
ISO 24101-2:2010	Intelligent transport systems–Communications access for land mobiles (CALM)–Application management–Part 2: Conformance test
ISO 24102:2010	Intelligent transport systems–Communications access for land mobiles (CALM)–Management
ISO 24102-1:2013	Intelligent transport systems–Communications access for land mobiles (CALM)–ITS station management–Part 1: Local management
ISO 24102-3:2013	Intelligent transport systems–Communications access for land mobiles (CALM)–ITS station management–Part 3: Service access points
ISO 24102-4:2013	Intelligent transport systems–Communications access for land mobiles (CALM)–ITS station management–Part 4: Station-internal management communications
ISO 24102-5:2013	Intelligent transport systems–Communications access for land mobiles (CALM)–ITS station management–Part 5: Fast service advertisement protocol (FSAP)
ISO 24103:2009	Intelligent transport systems–Communications access for land mobiles (CALM)–Media adapted interface layer (MAIL)
ISO/TR 24529:2008	Intelligent transport systems–Systems architecture–Use of unified modeling language (UML) in ITS international standards and deliverables
ISO/TS 24530-1:2006	Traffic and travel Information (TTI)–TTI via transport protocol experts group (TPEG) extensible markup language (XML)–Part 1: Introduction, common data types, and tpegML

ISO/TS 24530-2:2006	Traffic and travel information (TTI)–TTI via transport protocol experts group (TPEG) extensible markup language (XML)–Part 2: tpeg-locML
ISO/TS 24530-3:2006	Traffic and travel information (TTI)–TTI via transport protocol experts group (TPEG) extensible markup language (XML)–Part 3: tpeg-rtmML
ISO/TS 24530-4:2006	Traffic and travel information (TTI)–TTI via transport protocol experts group (TPEG) extensible markup language (XML)–Part 4: tpeg-ptiML
ISO 24531:2013	Intelligent transport systems–System architecture, taxonomy, and terminology–Using XML in ITS standards, data registries, and data dictionaries
ISO/TR 24532:2006	Intelligent transport systems–Systems architecture, taxonomy, and terminology–Using CORBA (common object request broker architecture) in ITS standards, data registries, and data dictionaries
ISO/TS 24533:2012	Intelligent transport systems–Electronic information exchange to facilitate the movement of freight and its intermodal transfer–Road transport information exchange methodology
ISO 24534-1:2010	Automatic vehicle and equipment identification–Electronic registration identification (ERI) for vehicles–Part 1: Architecture
ISO 24534-2:2010	Automatic vehicle and equipment identification–Electronic registration identification (ERI) for vehicles–Part 2: Operational requirements
ISO 24534-3:2010	Automatic vehicle and equipment identification–Electronic registration identification (ERI) for vehicles–Part 3: Vehicle data
ISO 24534-4:2010	Automatic vehicle and equipment identification–Electronic registration identification (ERI) for vehicles–Part 4: Secure communications using asymmetrical techniques
ISO 24534-5:2011	Intelligent transport systems–Automatic vehicle and equipment identification–Electronic registration identification (ERI) for vehicles–Part 5: Secure communications using symmetrical techniques
ISO 24535:2007	Intelligent transport systems–Automatic vehicle identification–Basic electronic registration identification (basic ERI)
ISO 24978:2009	Intelligent transport systems–ITS safety and emergency messages using any available wireless media–Data registry procedures
ISO/TR 25100:2012	Intelligent transport systems–Systems architecture–Harmonization of ITS data concepts
ISO/TR 25102:2008	Intelligent transport systems–System architecture–"Use case" pro-forma template
ISO/TR 25104:2008	Intelligent transport systems–System architecture, taxonomy, terminology, and data modeling–Training requirements for ITS architecture
ISO/TS 25110:2013	Electronic fee collection–Interface definition for on-board account using integrated circuit card (ICC)
ISO 25111:2009	Intelligent transport systems–Communications access for land mobiles (CALM) –General requirements for using public networks
ISO 25112:2010	Intelligent transport systems–Communications access for land mobiles (CALM)–Mobile wireless broadband using IEEE 802.16

ISO 25113:2010	Intelligent transport systems–Communications access for land mobiles (CALM)–Mobile wireless broadband using HC-SDMA
ISO/TS 25114:2010	Intelligent transport systems–Probe data reporting management (PDRM)
ISO 26683-1:2013	Intelligent transport systems–Freight land conveyance content identification and communication–Part 1: Context, architecture, and referenced standards
ISO 26683-2:2013	Intelligent transport systems–Freight land conveyance content identification and communication–Part 2: Application interface profiles
ISO/TR 26999:2012	Intelligent transport systems–Systems architecture–Use of process-oriented methodology in ITS international standards and other deliverables
ISO/TR 28682:2008	Intelligent transport systems–Joint APEC-ISO study of progress to develop and deploy ITS standards
ISO 29281-1:2013	Intelligent transport systems–Communication access for land mobiles (CALM)–Non-IP networking–Part 1: Fast networking and transport layer protocol (FNTP)
ISO 29281-2:2013	Intelligent transport systems –Communication access for land mobiles (CALM)–Non-IP networking–Part 2: Legacy system support
ISO 29282:2011	Intelligent transport systems–Communications access for land mobiles (CALM)–Satellite networks
ISO 29283:2011	ITS CALM mobile wireless broadband applications using communications in accordance with IEEE 802.20
ISO/TS 29284:2012	Intelligent transport systems–Event-based probe vehicle data

Despite having so many industry and application standards in various verticals of a smart city, there is a strong need for the development of comprehensive standards that will encompass all of the competing technologies and protocols to best fit end-user demands and aspirations. In the smart city business there is nothing which is "one size fits all."

Hence, the rush for standardization seems to be endless.

[1] [Online]. Available: http://www.itu.int/en/ITU-T/focus-groups/ssc/Pages/default.aspx

[2] [Online]. Available: https://www.itu.int/.../ITU.../web-fg-ssc-0274-r4technical_report_standardization_roadmap.doc

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* For example, Facebook provided support in terms of SDK Tools that promoted the development of millions of APIs that helped the complete ecosystem grow around it.

[1] [Online]. Available: http://www.standardsuniversity.org/trystandards/

[2] [Online]. Available: http://www.itu.int/en/ITU-T/focus-groups/ssc/Pages/default.aspx

[3] [Online]. Available: https://www.itu.int/.../ITU.../web-fg-ssc-0274-r4technical_report_standardization_roadmap.doc

Smart City:
Standardization and Compliance Indicators

by Dr. Anil Roy

A working document on the industry connections activity initiation document (ICAID) of the IEEE Gujarat Section

When on April 3, 1973, Martin Cooper, a Motorola engineer, dialed up their competitor, Joel Engel of AT&T, for the world's first cellular telephone call from his brick-shaped device while walking in the street, nobody could have realized that this was going to be a disruptive technology in the coming decade and would continue to be today [1].

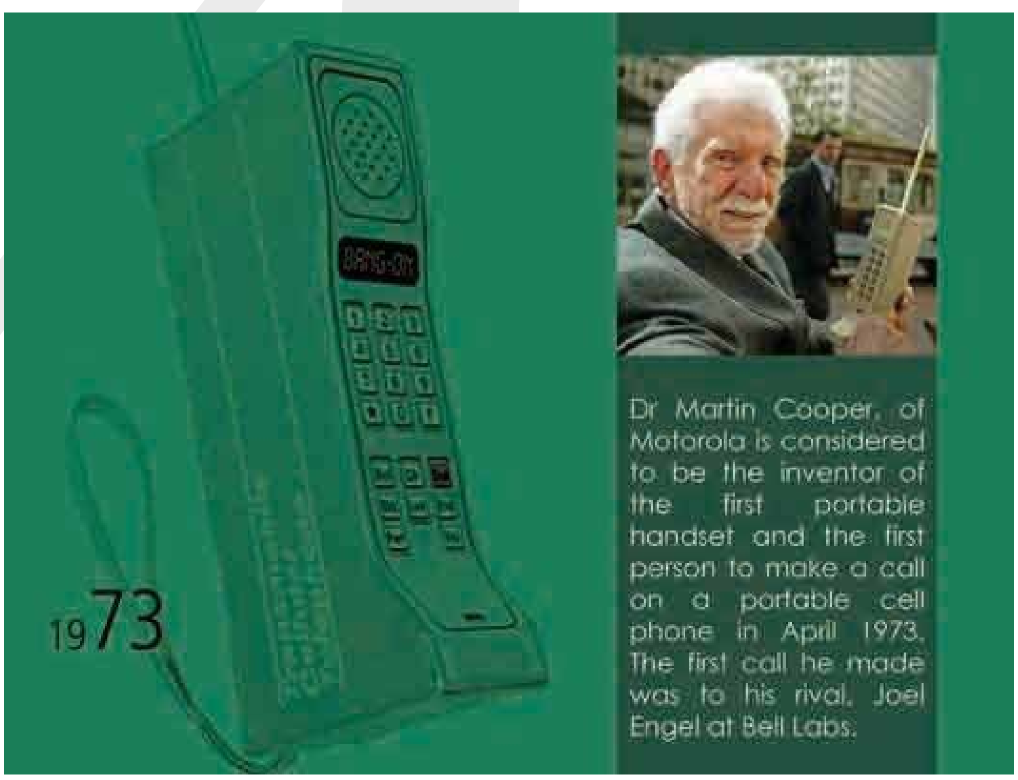

Fig.1. Dr. Martin Cooper and his fist brick-like mobile device. In less than four decades, mobile phones became smart phones, and have changed the social, cultural, economic, and political equations the world over. Thus, the world has become a global village.

The public launch of Friendster in March 2003 [2] (by Jonathan Abrams, a Canadian programmer) gave birth to the disruptive technology-intensive platform that evolved as "social networking." Interestingly, even its former CEO, Kent Lindstrom, saw it as nothing more than "the idea was to have the Internet do the work of a dinner party" [3]. The senior editor for internet and technology of Fortune magazine, David Kirkpatrick, also predicted in the same way [4], "There may be a new kind of internet emerging−-one more about connecting people to people, than people to websites," or as visualized by Mark Pincus, an investor in Friendster and founder of Tribe.net, as a "peopleweb."

We are living in an age where we are witnessing an explosion of innovation supported by killer technologies triggering disruptions. The complete business landscape of opportunities and challenges is accelerating at a whooping rpm. This is the "digital age." This accelerating change is supersonic, or even much more than that. It is like floating in a gravitational field of 4G. Businesses have to acclimatize and evolve in sync with this pace. Otherwise, they will perish once they reach a tipping point.

These companies need a digital strategy in black-and-white, and the sooner the better [5]. But unfortunately, the rate of change is so fast it is accelerating at a geometrical progression (we always learned in our high school physics class how to deal with systems with constant acceleration using Newton's laws of motion, but we were never taught how to write equations of motion when the rate of change of acceleration is also non-zero). This has created a perpetual skill gap. The catch is that in this age of disruptive technologies, if you cannot disrupt your competitors, they will disrupt you. Barnes & Noble, Casio, Kodak, Lucent Technologies, Lotus, MySpace, Nortel, Novell, Polaroid, Silicon Graphics, Sun Microsystems, WordPerfect, are only a few examples of companies of the past. On the other hand, Google disrupted mobile phones (by introducing Android); Facebook and WhatsApp killed SMS (short message service); Netflix cornered the market on content streaming; Amazon shattered the eBook segment (with Kindle); Tesla is reincarnating energy storage systems (by launching Tesla Powerwall); and so on and so forth, to make you feel the thunder [6].The joint venture between MIT and Harvard in delivering edX tells us secretly that even the education sector is feeling the heat of disruption.

All this converges to a platform where we need to understand where the world has been heading. Volcanic eruptions and atomic explosions change the landscape. A technological big bang changes our lifescape; the way we live. The trending lifestyle is living in a smart city. When technologies are capable of serving you better, in a more secure and convenient way, why not live king-size.

The economic canvas of world cities has been in turmoil, too. The City 600, as termed by the McKinsey Global Institute, has been responsible for 60% of global growth, but within this group the 577 middle-weight cities are predicted to shift the center of mass of the global economy by 2025 [7], and it will shift to the southeast–hot spots are China, India, and Latin America.

The Indian minister for Urban Development and Parliamentary Affairs, Mr. Venkaiyah Naidu, told on the occasion of the seminar "Smart Cities for the Next Generation: International Conclave of City Leaders" [8] on 12 January 2015 that the urban population (31% of total population) of India makes up 63% of the country's GDP. The largest 100 cities of India, comprising 16% of our population and only 0.24% of our land area, account for 43% of GDP. This intrinsic linkage between urbanization and economic growth has prompted the government of India to announce the Smart City Mission. A budget provision of USD$15 billion was made in the financial year 2014–2015, and a formal mission statement and guidelines of the "Smart City: Mission Transform-Nation" was announced in June 2015 [9].

Parallel to this, IEEE Gujarat Section's volunteers, in resonance with IEEE-SA (IEEE Standards Association) leaders, were contemplating the term "smart city" and how it has been perceived globally. This effort culminated in formal approval of the industry connections activity initiation document (ICAID) with the objective of defining "Smart City--Compliance Indicators." The motivation behind this initiative was to make a sincere attempt to design something similar to the CMM level indicators [10] of software development industries or the hotel rating system [11].

Cities around the world are already making tremendous progress in achieving economic, environmental, and social sustainability by implementing innovative systems and services. These are excellent ways to improve city living standards and economies. The concept of smart cities doesn't compete with these efforts. In fact, a smart city augments these objectives by leveraging cutting-edge technologies. It supports and enhances the quality of work that is already underway.

The term "smart city" is conceived differently in different parts of the globe. It is either used interchangeably or loosely. The interpretation is based on the context in which the term is used. The goal of the proposed activity is to come up with the definition of a smart city and the factors that determine the "smartness" of a city. First, the "indicators of smartness" that are must for a city to be called a smart city will be identified. Based on these indicators and their impact on the overall environment of the city, a ratings index will be developed.

The basic thought process is that in order to be consistent and uniform in the development of a smart city, the developer must follow some standards. These could be standard procedures, standard technologies, standard protocols, standard interoperable features, etc. So the first stepping stone for reaching a uniform and objective scale for setting up a smart city starts with an investigation into applicable standards. It is necessary to produce a list of indicators that should be looked into very carefully by the promoters of a smart city. These indicators will give an idea of the degree of compliance that a city will need to adhere to in order to be called a smart city.

The word "smart" has of late evolved as a concept which is pervasive and addictive. We tend to call everything "smart," viz., smart phone, smart light, smart TV, smart fridge, smart oven, smart chair, smart device, smart energy meter, smart wearable device, smart watch, smart glass, smart grid, smart home, smart parking, and the list goes on. Loosely interpreted, "smart" means "intelligent." The infrastructure and overall city facilities may be called "smart," if they deliver many services without getting affected by moods and emotions, consistently and repeatedly. The quality of service (QoS) of these services is ideally adaptive to local changes in the parameters. For example, a smart street light system will dim the intensity of street lights if no motion is detected for a set duration, and will immediately turn on if a car is sensed on the road. This simple example indicates that smartness is driven by how these smart devices sense the parameters, in another way, by "sensors."

So what makes a sensor intelligent? A sensor senses the physical parameter it is intended to sense. We can say that the sensor ***collects*** the reading ("data"). Then those data are sent to a router or a base station that is programmed to send the data to another server ("cloud service'"). This "sending" may be done on a wired or wireless network or connection. We can say that the base station ***communicates*** with the cloud service. The action takes place here. At this point the data is assembled, distributed, processed, makes decisions, and decides on further action. This is what we call data analytics. This step is like crunching the data. Once all of this happens and happens repeatedly, continuously as it is designed for, we say that our system has acquired intelligence and one may call this a "smart system." From this brief scenario, we may conclude that a smart system

- Collects, communicates, and crunches data,
- Performs (actions), presents (information), and predicts (what's next).

From our familiar knowledge, we may say that it is a larger picture of an Internet of Things (IoT) application. This smart system could be anything, starting from a smart pen to a smart city. In a smart city sense, more factors add up in the deliverables, such as

- It ensures workability, sustainability, and ultimately livability for its citizens.

Use Case 1 (how a simple application of the smart city age may change the overall economic landscape of the world)
Taking a clue from one of the prime verticals of a smart city, transportation management, let's tear open the automotive ecosystem. Its stakeholders are: automakers, car dealers, retailers, government (as regulator and policy maker), oil and gas companies, auto insurers, healthcare insurers, hospitals, car repair shops, etc. If the vision of a smart city works, it has been predicted by McKinsey & Company's report [12] in 2015 that 90% of traffic-related accidents will be reduced. This is made possible through advancements in the production of AVs (autonomous vehicles) and ADAs (advanced driver-assistance systems). It would result in the disappearance of 90% of insurance premiums. Its immediate impact would be an annual saving of nearly USD$200 billion in the form of healthcare costs

associated with road accidents [13]. Insurers, hospitals, car repair shops, etc., will have to look for other business opportunities. It will also witness a paradigm shift in the automotive business model that will move from owning a car to a pay-for-use model. It will have a direct impact on the business model of automakers, dealers, and retailers. New business opportunities will boom. Mobile apps for pay-for-use and rent-a-car will grow by leaps and bounds.

Fig. 2. Google's iconic driverless car [14].

The technology drivers will enter into entirely different and challenging work areas. Some of the features that one cannot keep an eye off of in an ADA car are: parking assistance/vision, lane-change assistance, lane-departure prevention technology, adaptive cruise control, blind spot alert, cross-traffic alert, brake-assistance/collision avoidance system, 360 degree camera system, on-board diagnostics, infotainment, etc. These use radar applications, ultrasonic and microwave/RF technology, and hybrid tools and techniques to manufacture an ADA car in a foolproof environment. Similarly, V2V (vehicle-to-vehicle), V2I (vehicle-to-infrastructure), and collectively a family of V2X (vehicle to …) secured connectivity will attract the best of researchers. Also, intra-vehicle networking will impose never-ending demands on several technologies such as: CAN (1 Mbps), LIN (19.2 Kbauds), MOST (up to 150 Mbps), Ethernet (up to 100 Mbps on low-cost, unshielded twisted pair cables), FlexRay (10 Mbps), etc.

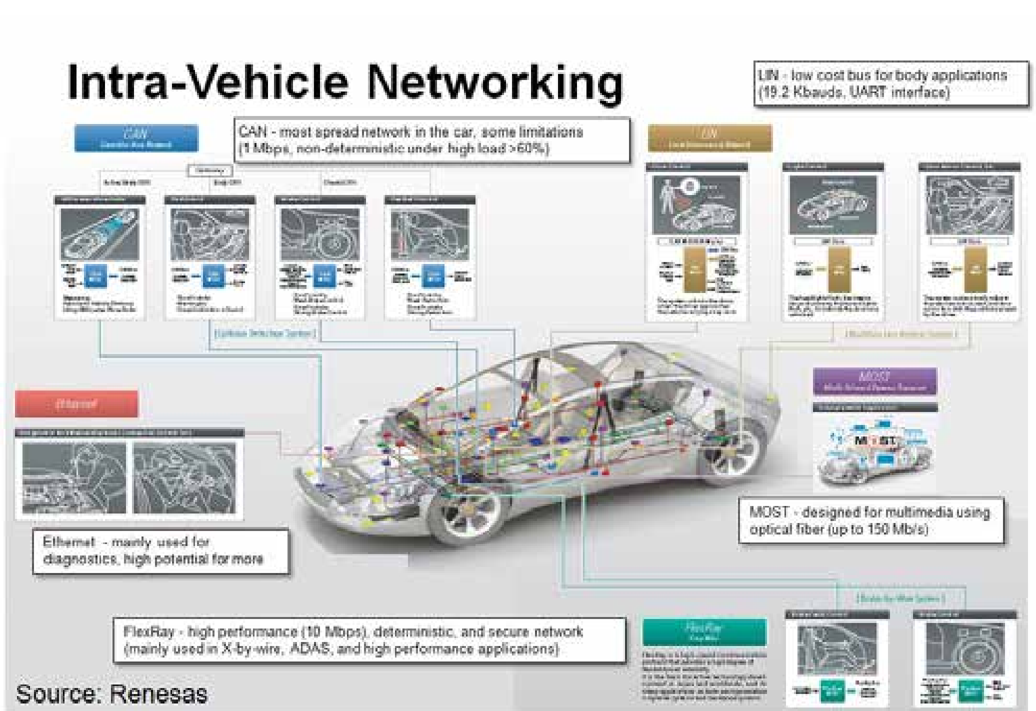

Fig. 3. Typical block diagram of in-vehicle networking [15].

Use Case 2 (how data management of the smart city has to be dealt with)
Let's take the case of data management in a smart city scenario. All verticals of the smart city churn out tons of gigabits of data/information each day. Gone are the days of 3G and LTE. Now we are heading towards 5G. On top of that, IoT applications, M2M technologies–all are growing on an accelerated pace. Imagine the terrific mobile traffic it would generate. This is big data. Massive connectivity among H2M, M2M, and D2D, demand of diverse services, low cost, low power, low latency, high throughput, high reliability, an unmatchable guarantee for QoS are all taken for granted. Therefore, the smart city data infrastructure has to be able to sustain this traffic and ensure these services. So, how to manage it? The implementer has to think through the complete information life cycle and not in bits and pieces. Therefore, as a first step, the government ('the implementer" or "the owner") must define information/data and in what format it will be generated/prepared. From a standardization point of view, the set format must

- Find ease in "interoperability" with other/prevailing standards,
- Take into consideration programming standards so that the developers of APIs (application programmable interfaces) find it hassle-free to work on.*

Once the definition and format are fixed, guidelines followed by SOPs (standard operating processes) need to be put in place mandatorily to be followed for
- Acquiring,
- Validating,
- Storing,
- Protecting,
- Processing, and
- Deleting the data.

Besides the above, the implementer also has to consider
- Regulations at the user end,
- Latency and throughput to get the information,
- The ID or address in-network and the application layer to ensure security,
  - How to take backups,
  - Requirements for the datacenter, etc.

For high-end APIs, the name and version of the security software, the database, information retrieval, fingerprint/biometric tools, machine learning, data/video compression, forensics tools, and other middleware software are to be provided and properly upgraded regularly. Thus will ensure protection from cloning, the creation of fake identities, fishing, vishing, smishing, slow or no recovery from attacks, unauthorized overwriting of data, and other basic privacy issues. In the absence of these fundamental policies, one may completely put the entire smart city infrastructure at a standstill. Contracting the above to a third party as a corrective measure will certainly impact the cost of data guarantee and insurance services.

Use Case 3 (general awareness about use of technology/services)
We want to raise a serious concern here in the broad perspective of the smart city. Despite having so many professional and competent groups contributing to make our experience of living in a smart city a comfortable, convenient,

and productive experience, the lack of awareness of the use of these technologies and services may cause immense damage in terms of financial loss and/or reputation.

Let's look at a use case of a home scenario. WhatsApp claims that communication/transactions on its network are end-to-end secured. All four persons (wife, husband, son, and daughter) communicate on WhatsApp leisurely. They have one data connection for their home, and they create a hotspot within the home so that all of them can use the data service on the home Wi-Fi system created by the hotspot. They are not aware of the security issues of an unsecured wireless network, and therefore whenever the Wi-Fi starts, one of their smart neighbors enters their home network and gets access to all the data transactions this family has been performing. This neighbor can fake/clone/steal the identity of one of the family members, and may misuse the data with malicious intent. This case, from a layman's perspective, conveys that the security of the home Wi-Fi network is the responsibility of the home users and not of the service provider.

Therefore it becomes the obligation of the implementer (for example "the government") to train citizens of the smart city, and groom them to use its features and services in the most secure and best way.

To sum up, this article touches upon various aspects of current scenarios of the smart city initiative. The authors wish to highlight a very important aspect of a smart city–-it has to be citizen-centric. Right now it has been emerging as technology-centric, driven by, possibly, the commercial interest of industry giants in this domain. What will happen to poor people, in terms of low awareness and/or low affordability, who use the technology? Will they be thrown out of the boundaries of so-called smart cities? Only time will tell how much governments will be sensitive towards protecting the interest of all its citizens or will they become a simple toy in the hands of industry giants? The policy on Human Capital Valuation, therefore, becomes equally important for a forward-looking government.

We hope that the "happiness quotient" of a smart city will be one of the indicators of the "smartness" of the city.

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** For example, Facebook provided support in terms of SDK Tools that promoted the development of millions of APIs that helped the complete ecosystem grow around it.*

Smart Cities, Big Data, and the Internet of Things

by Fábio Duarte, Carlo Ratti

Werner Herzog, the prolific filmmaker of iconic movies such as The *Enigma of Kaspar Hauser* and *Fitzcarraldo*, recently wrote and directed *Lo and Behold*, a film exploring how the Internet has been changing the world and human relations as dramatically as language itself. Herzog depicts the marvels and risks of society's reliance on the Internet, which can connect people and build social power, but can also result in catastrophic consequences if the network is disrupted. In his multifaceted view, Herzog makes clear that our society needs the Internet, but remained silent when Jason Tanz of *Wired* asked: "Yes, but does the Internet need us?".

smart-cities-big-data-and-the-internet-of-thingsThe Internet is the infrxastructural backbone of the massive exchange of data that is produced and exchanged every second. In 2015, mankind produced as much data as it created in all the previous years of human civilization. And still, data generation continues to grow exponentially. Today, the amount of worldwide data produced doubles every 12 months. Soon, it will double every 12 hours [1]. In only four years, the world will reach 3.4 networked devices per capita, with the global IP (internet protocol) traffic growing 22% annually between 2015 and 2020 [2].

The underlying reason for this growth is the increasing communication between devices––or the Internet of Things (IoT). In fact, machine-to-machine IP traffic will grow 44% each year until 2020 [2]. Essentially, the Internet is entering the physical space, not as an additional layer, but as its very essence.

Digital technologies are increasingly being woven into space and integrated into the very material fabric of cities. We are now experiencing the convergence of digital information (bits) and the physical environment (bricks). Cities are becoming hybrid composites of "bits and bricks," of materiality and information––bound together by cheap, small, and powerful computers. These devices are quickly transforming our cities into "computers in open air." Sensors embedded in our phones, computers, and cars, as well as in streetlights and buildings, collect huge amounts of data of our daily activities through active and passive means. We are surrounded by an invisible "smart dust" [3], large-scale networks of wireless sensors that enable space to sense, intercommunicate, and activate.

Through pervasive technologies and ubiquitous computing, data is "gradually becom[ing] a part of how we see the world" [4]. At the core of smart cities a key question arises: How can big data and the IoT be used for urban analysis?

To foster the integration and cooperation of different devices in the context of smart cities, international standardization bodies play an important role, with the goal of avoiding the creation of intranets of things, where many small networks of devices work in isolation. This would remove the main value of IoT, which is the collaboration between different devices to obtain a better understanding of the surrounding world. For this reason, standardization efforts are actually focused on communication stacks, including application and transportation layers for IoT solutions; protocols based on the publisher-subscriber paradigms; and routing protocols supporting point-to-point, point-to-multipoint, and multipoint-to-point communications flows.

However, the beauty of the IoT and data analytics is beyond devising algorithms to solve complex mathematical problems. Rather, it relies on uncovering the stories behind what apparently seems to be only anonymous data, understanding the consequences of all of this, and designing cities that leverage the potential of these technological shifts. Applications can range from detecting the presence of people and activating lighting, heating, and cooling systems accordingly; building using materials that react to temperature changes and lighting conditions (both with huge energy-savings benefits); creating augmented-reality experiences; and employing the sensors already embedded in our devices to diagnose urban infrastructure.

This article illustrates some of the work by the MIT Senseable City Lab on mobility. If the car is widely considered one of the major forces shaping cities in the 20th century [5], ICT-enabled (information and communication technologies) mobility is likely to shape the 21st.

In New York City, the more than 170 million taxi rides per year reveal the pulse of the city. At the MIT Senseable City Lab, rides of the more than 13,500 Medallion taxis in New York over 40 billion possible street segment pairs were mapped. The analysis of all these trips not only shows how people move around the city, but also helps to discover other potential benefits from this rich dataset. For example, by matching each trip's pick-up and drop-off points with the starting and ending time, researchers modeled trip-sharing opportunities, introducing the concept of "shareability networks" [6]. It was discovered that with minimal inconvenience to passengers, sharing could reduce the number of trips in New York by 40%––thereby reducing car-related emissions, and resulting in economic savings for millions of people.

Shareability could be enhanced when coupled with driverless cars that will be increasingly circulating in cities over the coming years. As vehicles begin to connect with each other and exchange data online, a "moving web" could emerge–-a moving web which would collect data of multiple transportation modes, generating real-time information of how, where, how fast, and by which modes people move. Imagine a unique platform to share mobility information among all transportation providers, creating a more transparent marketplace for online transportation and logistics services, and a level playing field for all entrants and users. MIT research[1] shows that the mobility demands of a city such as Singapore could be satisfied by just one-fifth of the number of cars currently in use. Such reductions in car numbers would dramatically lower the cost of our mobility infrastructure and the embodied energy associated with building and maintenance. Fewer cars may also mean shorter travel times, less congestion, and a smaller environmental impact.

The correlation between how, when, and where people move about a city and human exposure to pollutants is crucial public health information. As people move throughout a city, they leave behind digital breadcrumbs. Revealing such movements can literally save lives. Air pollution is responsible for over seven million deaths each year, a problem that is more acute in urban areas. Although New York has an extensive network of 155 stations to monitor air quality, studies of human exposure to pollution have considered a person's location based on Census data. The problem with this data is that it is based on a person's residence–-and therefore considers people fixed in space and time. In order to tackle this problem and to understand a person's location in different parts of the city at different times of the day, 121 days of 3G mobile traffic data from several operators and different types of mobile devices were analyzed. By matching a person's movements with air pollution measurements, it was shown that areas considered to have low exposure rates to pollutants based on a person's residence, such as Midtown Manhattan, actually had the highest exposure when a person's movements were taken into account [7]. By combining different urban datasets that are not usually seen as part of the same phenomenon, data analytics can create new ways of understanding urban and environmental dynamics.

Big data and the IoT are revolutionizing how we understand, design, and manage cities. However, the over-reliance on data analytics without considering its context risks creating a data-driven technocracy where any unexpected behavior is suspicious. This particular view of smart cities eliminates the possibility of being surprised, of experiencing unforeseen phenomena, and of being challenged by unexpected outcomes for which there are no protocols and standards. As we generate and exchange huge amounts of data, "smartness" should also generate new information about the different human behaviors that arise when we are confronted with unexpected situations, and the emergence of new ideas and ways to think and experience the world.

This paper puts forward the necessity of a change in the paradigm of how we treat and discuss the smart city. "Smart city" has become the buzzword for urban planning in recent years. In fact, the term "smart city" has been overused and sometimes abused over the past few years. That is why it is preferable to use the term "senseable city" instead, because it emphasizes the human side, instead of the technology side, at the center. The word senseable has a double meaning; it means "able to sense" and "sensible." The common denominator of all of the Senseable City Lab's projects, including those discussed in this paper, is that they are focused on people, rather than technology per se. The fact that our cities are becoming "senseable" is simply the manifestation of a broad technological trend. The Internet is entering the spaces we live in, and is becoming the IoT, impacting our ways to understand, design, and ultimately live in cities.

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Promoting Technical Standards - Education in Engineering

by Daniela Solomon and Janet L. Gbur

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Abstract

The United States Standards Strategy, the framework developed by the American National Standards Institute (ANSI) to guide the U.S. standards system, recognizes the need for standards education programs as a high priority and recommends initiatives that address the significance and value of standards.

To this intent, a novel workshop was developed in partnership with the library and the School of Engineering to raise the level of awareness of technical standards and standards usage on campus. The effort was a result of a campus-wide collaboration that provided a low-cost method of introducing technical standards and providing a foundation to develop a series of online tools accessible to the campus community. The event featured guest speakers representative of six major national and international standards bodies in addition to faculty, staff and students. The panels provided discussions on the background of the various types of standards and industries impacted, the development and implementation of these documents, the ways in which students and faculty can become more familiar with these documents and the benefit to becoming actively involved with standards organizations. The presentations and question-and-answer sessions provided a venue to learn about technical standards and to talk about ways to improve standards education within the campus community. The event was well received as shown by strong attendance and follow up to online materials continues to show activity five months following the event.

This paper summarizes the implementation of the workshop, its impact, and strategies to further improve standards education on campus.

Introduction

Technical standards are recognized as essential for economic growth and for facilitating global trade system liberalization. Recognizing the overall importance of standards, the American National Standards Institute (ANSI), in collaboration with other national organizations, has developed the United States Standards Strategy (USSS) that states that simple familiarity with standards is not enough but that there is need for firm education on the fundamentals of standards and their respective implementation.1

It is widely recognized that engineering students do not get much exposure to standards while in school.2-4 Through a study done in 2004, it was revealed that standards education was not considered a priority at the institutions surveyed.5 However, employers have expectations that new hires have knowledge of standards and their applications.3,4 Additionally, many standards developing organizations (SDO) encounter difficulties in recruiting the experts and leaders that can ensure successful continuation of their mission.6 As a result, the Unites States Standards Strategy established standards education as a high priority in the U.S.

Efforts in that direction started in 2000, when ABET, recognizing the benefits of including technical standards into engineering education, included a reference to standards and codes in General Criteria, Criterion 5, requiring that all major design experience should incorporate appropriate engineering standards. Moreover, to provide additional opportunities for education on standards, many SDOs have established education committees with the goal to assist engineering and technology programs. Standards education is accepted as highly beneficial to engineering students6-9 but there are discussions whether it should stop at introducing the theoretical rules and use7 or should it also include the development process.10

The most effective way to introduce standards to engineering students was determined to be by inclusion into engineering curricula or use of standards in the classroom.8-11 However, although recognized as efficient, standards inclusion into curriculum is still not common practice due to a variety of reasons. One of the main reasons is that engineering curriculum is highly intensive in technical subjects which, in turn, leaves little room for auxiliary courses on other topics of interest to engineers (i.e. project management, standards, ethics, etc.). Other reasons for the lack of curricula adoption is that many engineering faculty have little or no knowledge of practitioner standards6 and that training them to recognize standards value is time consuming,11 while textbooks and handbooks are quickly out of date since standards are reaffirmed or revised every five years.6 Moreover, the development of new courses or the changing of curricula is a challenging process.11 That is why the USSS recommends a concerted effort for identification of new ways to teach about standards, both from the universities and SDOs.1 Following this directive, many SDOs have developed a plethora of online training materials. However, these are difficult to discover, difficult to understand, and many times they are not available for free.6 Other initiatives include workshops organized in either collaborations by industry, government, and academia12 or as a singular effort. Initiatives from universities include use of standards in capstone projects12-13 and design classes.14-15 Academic libraries also play a role in standards education by providing campus-wide access to standards collections, teaching about standards through research guides,16 library instruction sessions,17 collaboration with faculty18 and organizing small scale local workshops, etc.

On our campus, the analysis of a library survey sent to returning co-op students by the engineering librarian revealed a strong need for standards education. There was also interest in developing a standards workshop from two graduate students who were active members of ASTM International. Through collaboration, plans had expanded from the initial idea of presentations by the two graduate students, to a workshop that would include two sessions – one session for the faculty and students representing the campus community and one session for representatives from national standards organizations.

Workshop Development

Due to the scope of the workshop, the key to its success was to gauge faculty interest early and ensure their cooperation for such an event. Throughout many meetings representing all School of Engineering departments, the faculty expressed enthusiasm for the workshop concept, contributed ideas on planning the event and had recommended organizations of interest to them. With the faculty help, it was decided that the best time for the workshop would be at the beginning of the fall semester. Some faculty deemed the workshop so relevant to their classes that they decided to include it in their syllabus for the fall and make it mandatory for their students to participate. One other very important idea suggested by faculty was that the workshop be recorded and made available online so that it could be available to those not participating in the workshop and enabling its content be reused in future courses. This initial planning step also helped secure the faculty speakers for the campus session.

The faculty enthusiasm was so great that the news about the workshop reached multiple offices on campus that were interested in offering event support. The Division of Engineering Leadership and Professional Practice (DELPP) office offered to sponsor the recording of the workshop and help with advertising to the engineering students. The office for Corporate Relationships provided a connection to and assistance in securing a speaker from a standards organization of great interest on campus. The Case Alumni Society, the Graduate Student Council, the Materials Graduate Society and the Materials Science and Engineering Department offered financial support to ensure a successful event. Finally, the library coordinated the video recording and means to have the videos available on campus and linked through the library website.

The main goals for the workshop were to increase standards awareness on campus – what are technical standards, the important role they have for the global economy and what benefits students could have by using standards. To reach these goals, it was necessary that the workshop provide a general introduction to standards and provide a forum to allow interaction between faculty, students, staff and standards personnel. In order to represent the extensive impact that technical standards have on a wide range of industries, it was necessary that a variety of different standards bodies and faculty from various disciplines be represented. This wide representation was necessary to maximize the reach to students of different engineering disciplines.

Consequently, the workshop was organized as two panels sessions, each including time for questions and answers. The first panel featured guest speaker representatives from six major national and international standards bodies identified as being of major interest on campus. The organizations included ASTM International, American National Standards Institute (ANSI), Institute of Electrical and Electronics Engineers (IEEE), Association for the Advancement of Medical Instrumentation (AAMI), CSA Group, and Underwriters Laboratories (UL). Their role was to discuss the background of the various types of standards and industries impacted, the development and implementation of these documents, the ways in which students and faculty can become more familiar with these documents and the benefit to becoming actively involved with standards organizations. The second panel featured four faculty representing Biomedical, Electrical, Mechanical and Aerospace, and Materials Science and Engineering, one graduate student, and the engineering librarian. Second panel speakers showcased standards work occurring on campus by sharing their experience in using standards in research, curricula or industry, involvement with standards development as well as standards availability through the library. Each presentation was scheduled to last five minutes to allow for fifteen minutes of questions and answers during each session. The two panel sessions were separated by a fifteen minute break that allowed for networking and discussions between the participants. Due to the rapid succession of presentations, a moderator for the workshop was also invited. The moderator, a NASA scientist, could also speak from his own experience working with standards.

The workshop was heavily advertised on campus using multiple venues. As the workshop was scheduled within one week from the beginning of fall semester, one email containing a short announcement was sent early in August to all engineering faculty. Multiple flyers and posters were posted around the campus and within the library before school started. During the first week of school, a second email was sent to faculty including all the details of the workshop, asking them to attend and recommend the event to students. Another email was sent to all engineering students using the internal listservers. DELPP office sent another email to all engineering students. Information about the workshop was published by the campus newsletter, library blog, Graduate Student Council website and all the electronic displays on campus. The library guide for standards was updated to include information on the workshop, PowerPoint presentations from all speakers, Technical Standards infographic19 with a very succinct introduction to standards (Appendix A) and to manage the registrations. The infographic was handed to all workshop participants. At the time of registration, participants' status and department were collected for assessment.

After the workshop, video recordings of all the presentations were posted on the university YouTube channel and linked to the library guide. In order to get feedback on the workshop, two different surveys were sent, one to all speakers and one to all participants. Questions on the survey sent to speakers dealt with their opinion on the workshop organization and whether they would consider participating again in the future. Questions on the survey sent to participants dealt with perceived benefits and learning experience offered by the workshop and whether they considered it a worthy event to participate in the future. A post event press release was published for the campus community and for the guest organizations.

Assessment

The event was evaluated in terms of campus participation, survey results from the panelists and attendees, event reach and event impact. Online registration was reported as 209 registrants. The breakdown of registrants is provided in Figs. 1a-c. Schools represented by the registrants included the School of Engineering, School of Arts and Sciences, School of Business and the library (Fig. 1a). As expected, the majority of the interest in the workshop came from the School of Engineering. Figure 1b breaks down the number of registrants by role within the university, separating by students, staff and faculty. Interest by the undergraduate population was particularly strong as 70% of the registrants represented undergraduate programs. Figure 1c shows a breakdown of the registrants by department. This provides insight into which departments overall expressed interest in the workshop. The Department of Mechanical and Aerospace Engineering and the Department of Materials Science and Engineering collectively represented 64% of the registrations.

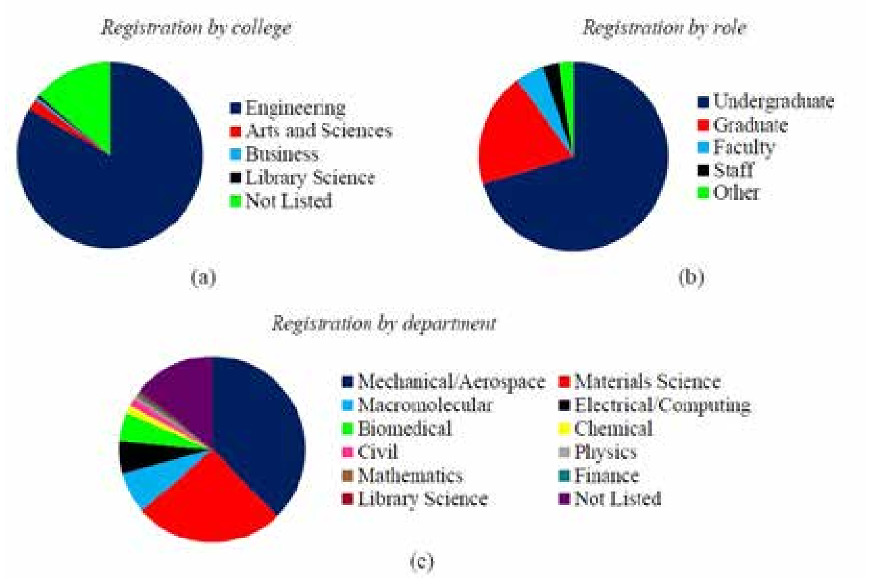

Figure 1. Breakdown of the workshop registrants by (a) college, (b) role within the university and (c) department

Feedback from the panelists was collected to help plan similar-type events through a post-event survey. Overall, the responses from the panelists were extremely positive concluding that the workshop was both well organized and of appropriate length. Specific suggestions to improve future workshops were made by panel members (denoted as "Other" in the Fig. 2). Many noted that the addition of an overview of standards presentation preceding the individual organization talks to provide an overview of the U.S. National Standards system would be beneficial. This would lay the groundwork for how each of the participating societies fit into the overall standards system. While an infographic on standards was distributed with electronic registration and as a handout at the event, the authors agree that a brief overview may have been beneficial at the onset of the workshop. The remainder of the respondents for that questions recommended focusing the workshop to a specific audience. Once the introductory material was presented, follow up sessions could concentrate on a specific discipline's needs, or look more in depth into a particular SDO.

At the conclusion of the survey, panelists had the opportunity to provide additional feedback. The primary concern was the time allotted for the individual talks as many felt it was too short to allow for an appropriate coverage of their organization's information. Many of the speakers found the five minute presentation difficult to adhere to and most talks ranged from slightly over five minutes to eleven minutes in length. The intent of the short presentation time was to allow for more time in the question and answer session. The author's believe that limiting the talks to ten minutes would allow for ample information coverage, but that it would be important to monitor the question and answer sessions and breaks more carefully to ensure the event did not go over time.

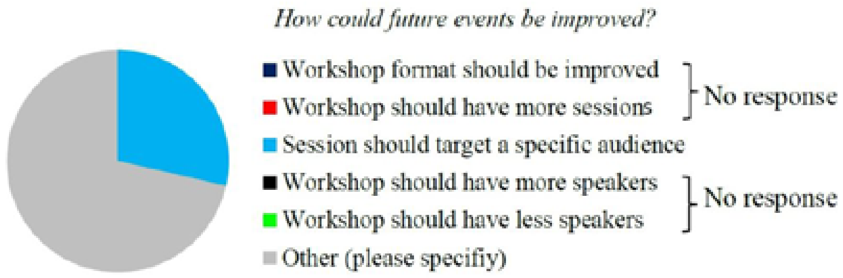

Figure 2. Results from the panelist survey based on how the event could be improved

The results of the attendee survey mirrored the panelists' responses on the organization and length of the workshop again noting that it was a well-organized event and the length was appropriate, though a small percentage felt the event was somewhat long. In addition to these questions, the attendees were also asked to reflect on their thoughts regarding workshop content, suggestions for future events, if they would consider attending again and most importantly the benefit(s) from attendance. The attendees overwhelmingly replied that the topic was of interest to them and that some to most of the information was new. Considering the majority of the audience was composed of undergraduates, the workshop proved to be a great venue to introduce students to essentially new material. Interaction between the students and panelists was engaging and many lively discussions occurred during the question and answer period that addressed fundamental applications of standards. Attendees had the opportunity to provide suggestions to aid in planning future events as well as addressing the question directly by choosing from the responses as shown in Fig. 3. Similar to the panelists' responses, the attendees chose to provide their own suggestions which included a desire to hear more about the student advantages to becoming involved with standards and standards organizations, how could standards get integrated into the classroom if not currently done and to consider adding other SDOs to the panel. In addition, many respondents commented on the enthusiastic presentations and interactions between panel members and between the panel and audience during the first half of the workshop. Based on the survey questions and additional comments, the majority of the attendees would prefer an interactive workshop format that would be smaller in size. This would also allow the ability to target more specific topics in standards education and implementation.

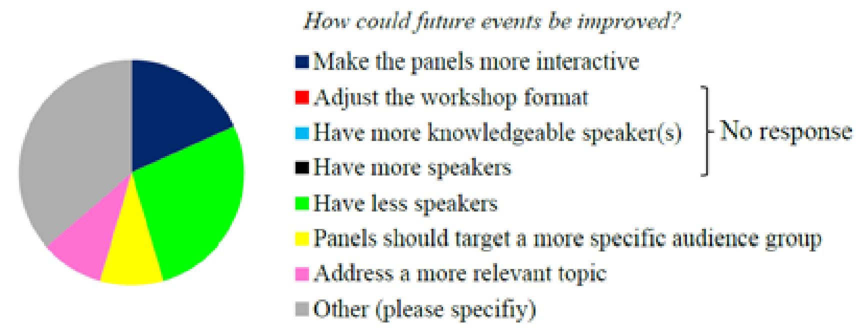

Figure 3. Results from the attendee survey on how the workshop could be improved

When asked about attending a future event on standards education, the attendees overwhelmingly agreed it would be of interest to them. Of the 75% that expressed an interest in attending again, half noted that a year in between workshops was an appropriate amount of time. Figure 4 shows the breakdown of responses.

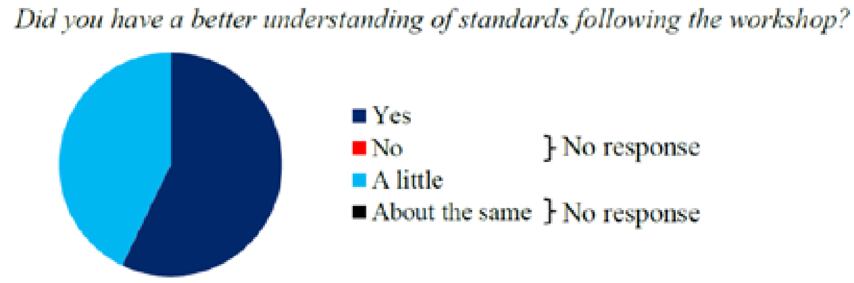

Figure 4. Results from the attendee survey on whether there was interest to attend a future workshop and if so, how soon

Finally, and perhaps most importantly, the attendees were asked about the benefit they received from attending the workshop. The questions were asked to generate a sense of how much the attendees were aware of the use of technical standards at the university and if upon completion of the workshop there was an improved understanding of what standards are and their usage. The majority of the attendees noted at least some awareness of technical standards used at the university. It would have been interesting to have asked more questions about their awareness, to perhaps better target information/awareness gaps for future sessions. Following the workshop, the attendees reported an increase (Fig. 5) in understanding of the material which met the authors' goal of improving standards awareness.

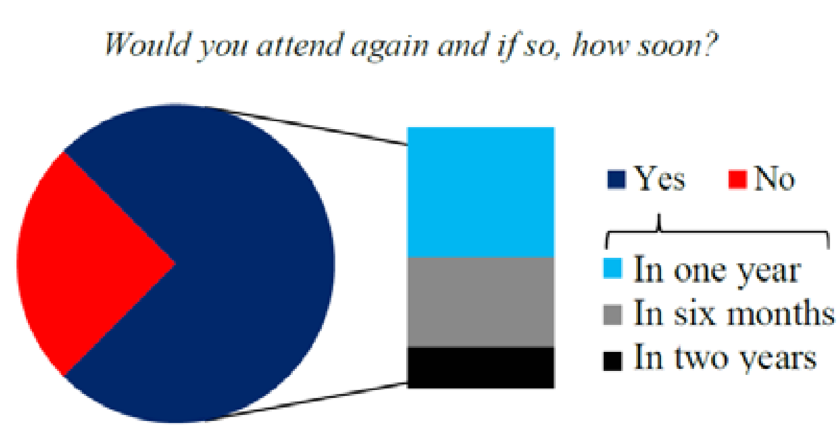

Figure 5. Results from the attendee survey on improved understanding of standards following the workshop

The reach of the event was measured by the number of times the online videos of the presentations were accessed through the university YouTube channel. These values provide an indication of interest in the presented material outside of the workshop attendance. Event videos and corresponding presentations were uploaded following the event. The number of viewings was measured at the beginning of January and resulted in a total of 584 views. A second measurement was made at the end of January which showed a 22% increase in views for a total of 714. This demonstrates a continued interest in the online materials and particularly the presentations related to the various standards bodies that participated in the event. Figures 6a-b depict the number of times presentations were accessed online with Fig. 6a providing the breakdown of views by panel type and Fig. 6b and by individual presentation.

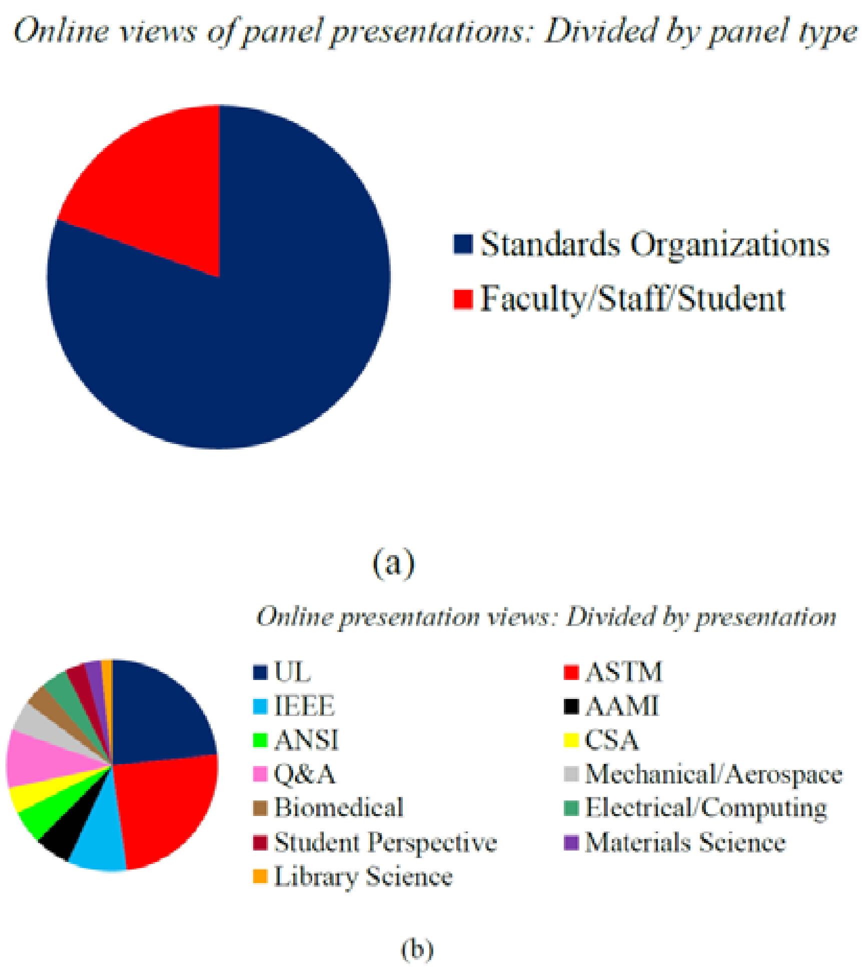

Figure 6. Views of online presentation videos broken down by (a) panel type and (b) individual presentation

In addition to videos of the workshop presentations which are hosted on the university YouTube channel, supplementary material on standards was also provided on the library website. This research guide provides resource material for faculty to use in the classroom, methods to find standards through the library, an overview of standards and all of the standards workshop information. In December, a new category was added to the online guide to address the use of standards in education. Examples of how faculty can implement standards education in the classroom are provided. Metrics from the site are noted in Fig. 7 beginning from September 3 (the day after the workshop) to January 31.

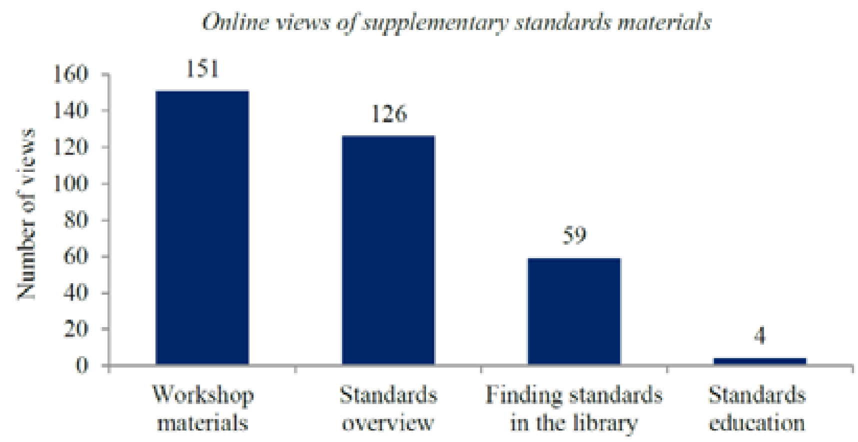

Figure 7. Views of supplementary materials on standards provided through the library research guides

Post-event impact was evaluated through the review of the participant surveys as noted previously, reach of message (news items linking back to the event), and classroom impact.

Surveys from the audience members demonstrated an increase in knowledge and exposure to standardization. Reach of the event and the ability for more individuals to have access to the workshop materials (i.e. handouts, videos) beyond the campus community was demonstrated by the coverage of participating organizations. An article (ASTM International) and news blogs (ANSI, AAMI) were uploaded to organization web sites noting the event and benefits of participation while another provided information on how to link back to the workshop materials (IEEE). News of the success of the event led to contacts from NIST for the faculty to become aware of grants to develop programming for the classroom which two faculty are in the process of pursuing. Some attending faculty used the event as a class activity. Design for Manufacturing I, Design for Manufacturing II, and Structural Materials by Design courses each used the event as an opportunity to introduce the concept of standards. The design courses used the workshop as in introduction to standards then following the event discussed how the standards would be applied to their design projects; both classes were expected to reference the applicable standards for their designs. The Structural Materials by Design course used the online videos as part of a homework assignment wherein students were asked to review and summarize a presentation.

Conclusions

This paper presented a novel way to implement an introduction to standards to the campus community. The workshop was successful based on the good participation and feedback from the panelists and attendees. The key to event success was engaging the faculty. Coordinating with faculty to find ways to include the workshop material as part of a class discussion, homework assignment or other activity further exposed students to standards and reiterated their importance and impact. Furthermore, the online availability of workshop presentations and the low cost of implementation allow for the development a flipped classroom model.

Another key element was identification of SDOs based on the needs of the campus community. This ensured a strong interest from faculty and students alike and provided reasons for good participation. The SDOs welcomed the opportunity to participate in the event and were very supportive of the initiative. Their actions following the workshop proved they found the event beneficial and would like to expand it to other institutions. Continued investigation and collaboration with educational outreach committees will enhance such future events.

While the overall event was extremely successful, there are several ways that the workshop could be improved. As noted by the panelists, an introductory presentation should be included and could easily be delivered by the event moderator. The presentation should be a brief introduction to the U.S. Standards System and how each of the presenting organizations factor into the overall program. The panelists also suggested that providing topics to cover in advance of the event would help keep the presentation length manageable and on target.

To help with targeting future events, particularly those that may focus on specific applications of standards, the request of additional information in the online registration could be beneficial. Collecting information prior to the event on basic knowledge, exposure or usage of standards would aid in determining the value of the workshop for the attendees. Based on the interest in the online presentations and supplementary materials provided through the library website, the authors consider that the development of an online presentation database to encompass a variety of SDOs would benefit a larger set of disciplines on campus. In turn, more faculty could utilize the materials in more classrooms.

The combination of workshops and an online presentation database could become an inexpensive and effective solution to expand standards education on campus without having to develop standalone courses or substantially changing existing curricula. In our experience, the School of Engineering, various campus offices and the library created the best partnership in making this event successful.

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Appendix A


TECHNICAL STANDARDS
Standards (procedures, rules, codes, regulations) are industry norms that provide a means of ensuring consistent design, quality, and safety of materials, components, processes, and services. Standards are developed by different industry associations for the benefit of their members and the industry as whole. By promoting uniformity and reliability, standards are an essential resource in engineering and related disciplines.
STANDARDS CLASSIFICATIONS
1
INTERNAL
PRIVATE
Proprietary
2
ASTM
IEEE
AAMI
ANSI
ISO
UL
$$$$
General Consensus
3
FDA
DOE
EPA
OSHA
DOT
FREE
Governmental
PURPOSE OF STANDARDS
SAFETY & RELIABILITY
Fire protection (NFPA)
National Electric Code (NEC)
etc.
REDUCE COSTS
Standard USB
Pipe sizes
Screws
Tire sizes
etc.
INCREASED FLEXIBILITY
Rail gauge
Light bulbs
Batteries
etc.
PROMOTION OF BUSINESS
Computer hardware
Materials standards
Standard tolerances
etc.
HELP SOCIETY FUNCTION
Credit cards
Barcodes
Street lights
WiFi
etc.
STANDARDS APPLICATIONS
#1 Materials for construction, performance criteria, and pertinent data
#2 Safe design rules
#3 Guidance for construction details
#4 Methodologies for inspections and testing
#5 Safe operating parameters
#6 Engineering software applications
STANDARDS BENEFITS
SOCIETY
Quality
Safety
Interoperability
Manufacturing
Globalization
Innovation
FACULTY
Research
Industry Outreach
Teaching
ABET Compliance
Professional Activity
STUDENTS
Engineering Design
Engineering Practice
Co-op & Internships
Ethical
Career Opportunity
Professional Activity
Technical Standards Workshop, September 2, 2015
Kelvin Smith Library
Case Western Reserve University
Fore more information see: researchguides.case.edu/standards
powered by
Piktochart
make information beautiful

Funny Pages

Standard Fare

by Guest Artist