ISO/IEC JTC 1

Information technology

Smart cities

Preliminary Report 2014

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
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1 Scope and purpose

JTC 1 recognizes the importance of Smart Cities as a trend that will shape many standards in the ICT sector, and notes a growing interest in this area among a number of standards setting organizations.

This document provides an overall review on the specified topics of Smart Cities exploring standardization opportunities for JTC 1.

This report aims to:

— provide a description of key concepts related to Smart Cities, establish the definition of Smart Cities based on the key concepts, and describe relevant terminology;

— study and document the technological, market and societal requirements for the ICT standardization aspects of Smart Cities;

— study and document current technologies that are being deployed to enable Smart Cities;

— assess the current state of standardization activities relevant to Smart Cities within JTC 1, in other relevant ISO and IEC TCs, in other SDOs and in consortia; and,

— identify and propose how JTC 1 should address the ICT standardization needs of Smart Cities.

2 Terms and definitions

This report uses certain terms as follows.

2.1 Defined terms

The following terms are defined elsewhere but used in the report.

2.1.1

key performance indicator

indicator of performance deemed by an organization to be significant and giving prominence and attention to certain aspects

[SOURCE: ISO 14031:2013 (en), 3.17]

2.1.2

Smart City

There are many definitions for Smart Cities in use globally

SAC – the general working group of Chinese national smart cities standardization, uses the following definition:

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Smart Cities: a new concept and a new model, which applies the new generation of information technologies, such as the internet of things, cloud computing, big data and space/geographical information integration, to facilitate the planning, construction, management and smart services of cities.Developing Smart Cities can benefit synchronized development, industrialization, informationization, urbanization and agricultural modernization and sustainability of cities development.The main target for developing Smart Cities is to pursue:

- *Convenience of the public services;*
- *Delicacy of city management;*
- *Liveability of living environment;*
- *Smartness of infrastructures;*
- *Long-term effectiveness of network security.*

(The above definition was translated from the latest Joint Directive Document published by eight ministries of the central government of China.)BSI PAS 180 provides the following working definition of a Smart City:*"Smart Cities" is a term denoting the effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens.*ITU-T Focus Group on Smart Sustainable Cities analysed nearly 100 definitions and used these to develop the following definition:*A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects".*ISO TMB Smart Cities Strategic Advisory Group uses the following working definition:*A 'Smart City' is one that...... dramatically increases the pace at which it improves its social economic and environmental (sustainability) outcomes, responding to challenges such as climate change, rapid population growth, and political and economic instability ...... by fundamentally improving how it engages society, how it applies collaborative leadership methods, how it works across disciplines and city systems, and how it uses data information and modern technologies......in order to provide better services and quality of life to those in and involved with the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment*ISO TMB SAG on Smart Cities is aiming to work with all the main standards bodies to develop a common definition, and so the recommendation of this report is for JTC 1 to collaborate with that piece of work, rather than aiming to develop its own definition.

2.2 Terms used in the report

2.2.1
evaluate (*v.*)
qualitatively appraise or analyse

2.2.2
model (*n.*)
description or abstraction of some aspects of reality

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2.2.3
need (*n.*)
general statement – by a human – of something deemed necessary

Note 1 to entry: As an expression of a general concern or desired outcome, a need is not stated in any formal manner nor does it necessarily contain any specific, measurable output.

2.2.4
outcome
net impact of one or a series of outputs

Note 1 to entry: An outcome might be achieved in different ways. An outcome is not necessarily predictable, desirable, or tractable.

2.2.5
output (*n.*)
result of an activity or use of some functionality within a system

Note 1 to entry: An output is specific and measurable. It may not lead to the desired or intended outcome (in case of error or system failure, for example). If it corresponds to a requirement, output should contribute to an outcome.

2.2.6
requirement
formalised statement of some desired functionality or end state achieved

Note 1 to entry: A requirement is specific and measurable. It should define an end state.

3 Abbreviated terms

This report uses the following abbreviated terms:

4G LTE	4th Generation Long Term Evolution wireless standard
SAC	Standardization Administration of China
BSI	British Standards Institution
FG	Focus Group
FTTH	Fibre to the Home
ICT	Information and Communications Technology
KPI	Key Performance Indicator
SAP	Special Advisory Group (of TMB)
SSC	Smart Sustainable Cities
TMB	Technical Management Board (of ISO)

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4 Smart City overview

4.1 Smart City concept

	City History and characteristics What is the city story, its "brand" and values? Is it a stand-alone city, a hub city or satellite city? What is the size of population? Is it growing, stable or shrinking? What is its demographic mix?	
Environmental context How flat or hilly On what kind of rock it is built If it is by the sea or inland Climate	**City actors** Local authority, Health trusts, electricity and gas suppliers, police, bus and tram companies, voluntary groups, businesses, banks, investors, education providers, social care providers, and, most important of all, the citizen. **Activities** Planning, managing, purchasing, regulating, building and repairing, providing services, generating profit, gaining finance ... **Community facilities and buildings** Homes, hospitals, schools, electricity substations, sports facilities, cinemas, water treatment plants, district heating plants, factories, offices, shops ... **Infrastructures** Gas, electricity, water, sewerage, telecoms, roads and rail, district heating systems ... **Soft Infrastructures** Business / Science / Community / Innovation networks and collaboration structures **Technical systems** Traffic light management, ticketing, billing and payment, automatic number plate recognition ... **City functions or service areas** Employment, Housing, Education, Health, Security, Mobility, Energy, Water, Waste Management, Food Supply chain, Consumer Goods Supply Chain .. **Scale** Citizen, building, block, neighbourhood, district, city, metropolis ...	**Societal context** Laws & regulations Division of power between national and city governments Division of power between agencies within the city Cultural norms Economic structures and situation Political context
	City Governance The task of City Governance is to ensure that all of the functions of the city are delivered effectively at all levels of scale, and are properly co-ordinated to best deliver on the city purposes. ↓ **City Purposes** The key challenges facing the city that need to be tackled and the opportunities that need to be grasped. Social, Economic, Environmental ...	

Figure 1 — City model

A city is a system of systems with a unique history and set in a specific environmental and societal context. In order for it to flourish, all the key city actors need to work together, utilising all of their resources, to overcome the challenges and grasp the opportunities that the city faces.

The "smartness" of a city describes its ability to bring together all its resources, to effectively and seamlessly achieve the goals and fulfil the purposes it has set itself.

In other words, it describes how well all the different city systems, and the people, organisations, finances, facilities and infrastructures involved in each of them, are:

- individually working efficiently; and
- acting in an integrated way and coherent way, to enable potential synergies to be exploited and the city to function holistically, and to facilitate innovation and growth.

There are many important areas of standards relating to both of these. However, the role of Smart City standards is focused on the second, in other words, on enabling the

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integration and interoperability of city systems in order to provide value, both to the city as a whole, and to the individual citizen.

4.1.1 Characteristics

In order to enable this to happen, a number of key characteristics are required:

- The city will be **instrumented** to allow the collection of increasing amounts of data about city life;
- The data from different sources and city systems will be available to be easily **aggregated together** to gain far greater insight into what is going on in the city;
- The **data** will be easily presented in a variety of formats, dependant on the context and the person or technical system needing it, allowing it to be **visualised and accessed more easily**, thus making it much more useful;
- **Detailed, measureable, real-time knowledge** about the city will therefore be available at every level, so that it can be easily accessed by whichever person or technical system would be able to use it to help fulfil their role or achieve their goals, within the context of the overall effective functioning of the city;
- In addition, **analytics and decision-making systems** will be used, so that this knowledge can be used effectively, both by city managers and planners, and by the citizen, to support real time decision making and enable effective actions to be identified that will enable future requirements to be met;
- The city will also be **automated**, to enable appropriate city functions to be delivered reliably, and effectively, without the need of direct human intervention;
- The city will have a network of **collaborative spaces**, to enable dynamic communities that will spur innovation and growth and enhance citizen well-being; and
- The continual interaction between the physical and digital worlds enables **the decision making processes to be much more open and inclusive**, so that citizens, policy makers and businesses can work together effectively to manage the life of the city for the benefit of all.

ICT has a key role in each of these.

4.1.2 Benefits

Smart Cities could therefore provide:

- Better and more convenient services for citizens;
- Better city governance;
- A better life environment;
- More modern industry, that is greener, and more people friendly;
- Smarter and more intelligent infrastructure; and

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- A dynamic and innovative economy.

4.2 Smart City models

The study group looked at a range of Smart City models and these have been collected in Annex A. In general there are two kinds of Smart City models:

- Simple models that aim to depict a Smart City in a single "picture" from a particular viewpoint. These provide a clarity and a good basis for showing how different sorts of stakeholders need to work together. Most of the models in Annex A are of this type and together provide a good overall picture of what a Smart City is.

  These models may seek to depict how the city works, such as in Figure 1 – city model in this report. They may attempt to categorise the different ICT aspects of a Smart City, as in Figure 3 in this report, which looks at it from the point of view of the role of the different standards bodies. As can be seen from Annex A, there is no single model that can capture all of the facets of a Smart City.

- Complex Models that aim to systematically describe all the elements in a Smart City down to many levels of granularity. These provide an important foundation for Smart City projects. These aim to develop a way of describing all of stakeholders, the activities, the relationships, the outcomes etc., of a city in a consistent way, no matter what city system or sector they belong to.

  One example of the second type is the Domain Knowledge model, see Figure A.2. The starting point for this is the requirement to develop a detailed systematic model for city ontology that could be used across all city systems and by all city stakeholders. This would enable data to be easily shared city wide and made available with consistent APIs so that developers could develop apps that straddle different city systems and so that services (such as payment systems, registration systems, management systems) could be reused across different city systems. It would also enable digital services that are developed for one city to be much more easily be ported to another city.

  Another example is the reference architecture/concept setting framework type models that several standards groups are working on, to help categorise standards in a systematic way so that they can easily be found.

  Another purpose for this sort of model is to underpin cross-system and cross-organisation management systems within a Smart City and to allow Smart City progress in different cities to be more easily compared and evaluated against each other.

All of the above models are linked and need to be developed in a way that ensures that they are consistent with each other. It would also be helpful for work on these different kinds of the second type of model to be done collaboratively, across all the SDOs, as they relate to the Smart City as a whole.

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4.3 Evaluation of Smart City outcomes

The survey results on the existing indicators for evaluating Smart Cities performance is in Annex E, which looks at two sources of city indicators; ISO/TC 268 and ITU-T Smart and Sustainable Cities Focus Group.

ISO/TC 268, which is focused on sustainable development in communities, has one working group developing city indicators and another developing metrics for smart community infrastructures.

The first standard produced by ISO/TC 268 is ISO/TR 37150:2014, was undertaken by this latter group and it provides a review of existing activities relevant to metrics for smart community infrastructures.

In ISO/TR 37150, the following indicators are referenced:

- Global City Indicators;
- Green City Index series; and
- Smart City realized by ICT.

Global City Indicators cover overall city life such as education, health, recreation, safety, transportation, wastewater, water, finance etc. None of these indicators are directly related to ICTs.

The Global City Indicators has now itself become an ISO Standard: ISO 37120:2014, ISO TC 268, and is being piloted by a number of cities. The intention is to continue to update and add to the standard, and this work is being managed by ISO TC 268 Working Group 2.

The Green City Index series cover CO_2, energy, water and transport etc. These are mainly focusing on indicators which are related to environmental impact and, again, are not directly related to ICTs.

Some indicators included in the Smart City realized by ICT (proposed by Fujitsu), cover the services and environmental impacts of ICTs but do not cover the performance of ICT itself.

The ITU-T Focus Group on Smart, Sustainable Cities is developing a Technical Report on KPIs that cover overall city life such as governance, transportation, security and safety, healthcare and some of these do cover the performance of ICT itself.

As a result of the survey, it was noted that most of the indicators cover overall city-life-related indicators but do not properly address the performance of ICT itself for Smart Cities.

There is therefore a need for ISO/IEC JTC 1 to develop new indicators for the performance of ICT within Smart Cities. This should ideally be done as an integral part of the city indicators being developed by ISO TC 268, Working Group 1.

Given that the ITU-T SSC Focus Group's Technical report on KPIs is not yet complete, it will be important to review the final version as part of any work JTC 1 might undertake in this area.

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5 Requirements for the ICT standardization aspects of Smart Cities

5.1 Introduction

There are two important considerations in introducing Clause 4 of the report that help in understanding the relationship between the Smart Cities "characteristics" (outlined in 4.1 above) and the consequent requirements for ICT standardization that emerge:

- The distinction between "needs" and "requirements" (and, in consequences, also between "outputs" and "outcomes");
- The focus on ***ICT*** standardization requirements.

Before identifying the needs and requirements that flow from those characteristics, we should establish a clear understanding of what is – and what is **not** – being considered in the remainder of this clause: understanding the ICT-specific standardization that is required to meet the needs of Smart Cities.

5.1.1 Need, requirement, output, outcome

A **need** is an expression – by humans – of something desired or deemed necessary. A need is not necessarily stated in any formal manner; it is more often expressed as a general concern or a desired 'end state'; it usually contains no specific measurable goal; and it does not necessarily even have to be realistic or realizable.

A **requirement** on the other hand is a formalized statement of some **functionality** whose **output** contributes to a desired **outcome** that, if achieved, will satisfy a need.

EXAMPLE A statement such as "we want safer streets at night" is a **need**. It is not very explicitly defined nor is there a specific, measurable end state. However, as citizens or policy makers, we may feel that "we know it when we see it". On the other hand, "There will be street lighting of sufficient luminosity to allow a pedestrian to see any point on a footpath or sidewalk and be seen by motorists" is a **requirement**. This is measurable.

A common concern in ICT is that requirements are sometimes formulated before, or in the absence of, any real articulation or understanding of what is the underlying need that is being addressed. While the **output** is unambiguous – more light on a sidewalk at night – that output does not necessarily result in the **outcome** that is desired. In our example above, there is no expression of what the speaker's need for "safer streets" would look like as an outcome: it could refer to better road surfaces or more clearly visible road signs that result in fewer accidents; it could refer to reductions of vandalism or street crime; it could refer to limiting opening hours of local clubs or bars with fewer incidents of unruly behavior or vulnerable people being accosted or attacked. It is important therefore to investigate a statement of need in order to articulate adequate requirements: specific **outputs** can, by their nature, be measured and tracked and be mapped against equally specific requirements; **outcomes** on the other hand are less predictable and tractable as indeed are the needs that they ultimately reflect.

There are often many, and very different, requirements that can satisfy a particular need. "All road signs should be illuminated"; "The relative dangers of poor roads should

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be evaluated at night"; "There will be a police officer on every street corner" could all be seen as perfectly valid responses to the same need in our example. **Context**, discussion and clarification of needs will all help determine which requirements are most suitable as responses.

This concern is particularly prominent in complex systems where underlying requirements are related to broad societal, economic, political or business needs. It will often remain the case that multiple requirements can express a specific need. We urge clarity in defining **needs** in sufficient detail. All relevant stakeholder groups should be involved in that process. It is only then that appropriate requirements can be formulated.

5.1.2 Focus on ICT standardisation requirements

In a domain as complex and multi-disciplinary as "Smart Cities", there will be many challenges for standardization. We see earlier in this report that the central role of technology is one of the defining characteristics of a Smart City. Indeed, "the concept of 'smartness' is addressed in terms of performance relevant to technologically implementable solutions, in accordance with sustainable development and resilience of communities, as defined in ISO/TC 268." [Source: ISO/TR 37150:2014, 1]

Fulfilling many needs in a normal city may not require 'technology' at all: if "safer streets" is understood in a particular context as meaning "reduction in petty crime", it may be that an overall improvement in socio-economic conditions reduces the likelihood of such crime without any other response.

There will be many standardization requirements for Smart Cities that go beyond ICT or do not involve technology at all. However, the increased prevalence of ICT in so many areas of everyday life means that even in domains that are not specifically ICT-*centred*, there are aspects that are nonetheless ICT-*influenced*. This prevalence of ICT is what can help transform a city into a Smart City. A socio-economic response to petty crime, for example, may not in itself seem to involve ICT but could benefit from detailed analytics of data from multiple sources that together can provide policy makers with sufficient relevant information to make decisions that have the desired socio-economic impacts. Such analytics are heavily dependent on ICT.

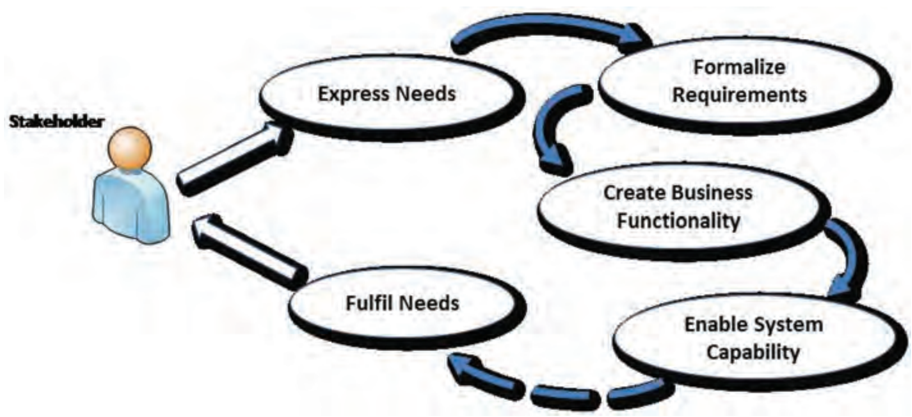

Figure 2 — Cycle of needs, requirements, and fulfilment source: OASIS SOA Reference Architecture Framework

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The work of ISO/IEC JTC 1 is scoped to consider ICT standardization. The challenge of this report is to identify the ICT-specific standardisation requirements based on an understanding of the particular needs of Smart Cities.

5.2 Mapping Smart City characteristics to needs

Figure 3

Cities have many needs in order to thrive: the scope of this report is concerned with those needs that are **characteristic** specifically of ***Smart Cities*** and with those requirements that are specifically in the domain of ICT. This can be visualized as follows:

Subclause 4.1 identified specific characteristics of Smart Cities and the fact that ICT has a role in *all* of the characteristics of what makes a city *smart*. We need to distil from those characteristics the particular needs that arise and in turn the specific ICT requirements that can fulfil those needs.

5.3 Smart Cities needs

5.3.1 Technological needs

Smart Cities are characterized by the availability of a wide range of technologies capable of working together to deliver complex systems and solutions. Smart Cities need robust and resilient technologies to help:

- Provide a shared understanding of the core concepts underpinning Smart Cities that can be used to develop coherent models and thus improve system interoperability;
- Facilitate instrumentation through the use of multiple types of device for sensing, capturing, storing, and exploiting the use of data from multiple sources, fixed as well as mobile;
- Make data exchange fluid and rapid between different types of network topology and using different types of communication and transmission;
- Facilitate the use and aggregation of data by systems and services that may not have initially generated them;
- Allow for data to be presented in a variety of formats, dependent on the context and the person or technical system needing it, allowing it to be visualised, accessed, and acted upon more easily, thus making it much more useful;
- Allow heterogeneous ICT-systems to work together;

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- Ensure that data is exchanged and used safely and securely; and
- Allow for greater automation that can enable city functions to be delivered reliably, and effectively, reducing the need of direct human intervention where and when this is appropriate.

5.3.2 Market needs

Smart Cities are characterized by an economic environment in which technological innovation can thrive and where innovation can in turn benefit and sustain such cities into the future. This environment needs:

- Adequate and appropriately trained workforces available to new business opportunities, able to work flexibly (e.g. teleworking) as needed;
- Adaptive learning spaces, coupled with distance learning tools, to allow ad-hoc skills development wherever students may find themselves gathered in the city;
- A marketplace that supports automatically discoverable services and resources, the matching of requirements with possible solution providers, as well as low-friction transactions;
- Stable and responsive (physical and digital) infrastructure that provides a basis for business establishment and investment; and
- Smarter infrastructure that can respond to both business and public sector requirements.

5.3.3 Societal needs

Smart Cities are characterized by a built infrastructure together with physical and virtual environments capable of sustaining the complex interactions between citizens, businesses, and services (whether public or private) who, together with policy makers, need to address economic, social and political challenges as they arise. Such challenges need:

- scenario-building, macro-economic and social modelling that takes due account of demographic trends and the ever-changing needs of the population;
- analytics and evidence that can support models and scenarios so that this knowledge can be used effectively, both by city managers and planners and by the citizen;
- More modern industry that is ‘greener’ and more people-friendly;
- citizens to play an active role in decisions regarding the life and future directions of the city; and encourage better city governance;
- decision-making supported by detailed, measureable, real-time knowledge about the city will be available at every level, so that it can be easily accessed by whichever person or technical system would be able use it to help fulfil their role or achieve their goals;
- Improved quality of life and safety of citizens and delivery of different services;

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- An appropriate balance, in the collection and use of personal information, between the legitimate desire of individual privacy and the collective social benefits of sharing (for example in the domains of public health and safety);
- a network of collaborative spaces, to enable dynamic communities that will spur innovation and growth and enhance citizen well-being;
- services that adapt to long-term challenges as well as short-term demands or emergencies; and
- a sustainable environment (air quality, waste management, adaptability to climate change and threats, etc.).

5.4 ICT standardization requirements for Smart Cities

From these needs – technological, market, and societal – we can identify a number of types of ICT standardization requirements

5.4.1 Understanding and modeling Smart Cities

Subclause 5.3.1 states that a shared understanding of concepts is needed and this is best achieved through formal models. Such models facilitate aggregation and heterogeneous system interoperability; as well as fluid, safe, and secure data exchanges, particularly across different system topographies.

The ISO TMB Special Advisory Group (ISO TMB SAG) on Smart Cities has indicated a desire to promote the coordinated development of a common conceptual model for Smart Cities that can be used across all standards bodies in their further standardisation efforts. Given the central role played by ICT in Smart Cities, JTC 1 should play a leading role in any such effort and should leverage the expertise available in a number of SC's as well as existing standards. For example, ISO 42010 provides a useful meta-model for the development of a domain model and that helps with identifying the types of stakeholder and types of ICT systems that together represent the unique "ecosystem" of a Smart City. ISO 10746 further helps identify the different views and viewpoints that make up the complexity of Smart Cities. Using these two existing standards – and the Service-Oriented Architecture (SOA) paradigm[1)] – will enable JTC 1 to direct work in the development of any specific formal models that are required. Furthermore, JTC 1 can provide expertise in developing leadership guides on the role that ICT and ICT standards ought to play in the development of Smart City strategies. Some examples of work to which JTC 1 should contribute are:

- **A Smart City framework**

  A Framework helps capture various cross-city governance processes that deliver benefits based on core guiding principles and taking due account of critical success factors.

1) As understood in its original sense as a paradigm of service composition and delivery across ownership boundaries in an environment encompassing both the real and online worlds.

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- **A domain knowledge model**

  The aggregation of multi-source and heterogeneous data and service needs a set of unified concepts and terminologies. In addition, the development of applications needs the support of common knowledge of Smart Cities. In order to support cross-domain and cross-city interoperation of knowledge, a core concept model specifies terms from different stakeholders, supports semantic understanding and provides a standardized expression of knowledge. Such a model should be completed with a taxonomy of (smart) device types (such as types of sensor, mobile devices, hardware, software, systems, etc.); Smart Cities sectors (such as health, transport, governance, etc.); and 'components' within each sector (such as medical devices, forensics/analytics, for health; buses, trams, railways, for transport; etc.).

- **A data and services model**

  Using the OSI[2)] as a template, a data a services model would reflect the data, communications, service and application layers that are used by citizens, businesses, and city authorities. Such a model would provide an adequate technical view of and for a more general Smart City model.

- **Data flows**

  Data is created in social and physical systems, collected, transmitted, stored and possibly shared before the data can be analysed, displayed and finally used to make decisions. At each step, different stakeholders are involved and technical challenges to be addressed (e.g. related to interfaces and interoperability) as well as social issues (e.g. privacy, security, monetization). Such data flows need to be observed within as well as between different systems and help understand where further standards may be needed.

5.4.2 Facilitating smart infrastructure, education, business, and services

All cities face challenges from urban planning, infrastructure development, education and training, decision-making and accountability, through to the deployment and use of goods and services. A Smart City is also a complex "system of systems", of both traditional systems, such as critical infrastructure, as well as new ones resulting from emerging technologies, such as virtualization, sensor networks, etc.

All aspects of a city's life – in particular those in a Smart City –are complex combinations of events in both the real world (and physical space) and digital world (of cyberspace) and many transactions and interactions take place in or between both. Wherever they take place, the outcomes are certainly felt in the real world of a city's stakeholders. There are many existing technologies (and often standards associated with them) in use in Smart City programmes but it is the need for ever more complex combinations of these together with emerging technologies – and a greater understanding of both the technological and social consequences of these combinations – that makes greater visibility and use of ICT

2) The Open Systems Interconnection model (OSI) is a conceptual model that characterizes and standardizes the internal functions of a communication system by partitioning it into abstraction layers. The model is a product of the Open Systems Interconnection project at the International Organization for Standardization (ISO), maintained by the identification ISO/IEC 7498-1.

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standards all the more important. This may require that existing ICT standards are re-visited and revised in light of the additional needs identified by Smart Cities and present new requirements to many existing challenges, such as:

- **Infrastructure and supply chain**

  Criteria for design, management and control of maintenance services for buildings

  Automatic vehicle and equipment identification

  Infrastructure and supply chain

- **Built environment**

  Building Information Modelling (BIM)

  Smart buildings

- **Transport, logistics, and service delivery**

  Electronic prescriptions and message exchange between health care providers and pharmacies

  Road vehicle schedule and control systems

  V2V communications

  Electric/hybrid vehicles and utility grid

  Freight identification and handling

  Public transport vehicle management and passenger information

- **Security**

  Cybersecurity is defined as preservation of confidentiality, integrity and availability of information in Cyberspace (see ISO/IEC 27032 Guidelines for cybersecurity). Cybersecurity relies on information security, application security, network security, and Internet security as fundamental building blocks. Cybersecurity is one of the activities necessary for CIIP (Critical Information Infrastructure Protection), and, at the same time, adequate protection of critical infrastructure services contributes to the basic security needs (i.e., security, reliability and availability of critical infrastructure) for achieving the goals of Cybersecurity.

  Therefore, the Cybersecurity standards in the context of Smart Cities are required to provide guidance for improving the state of Cybersecurity of Smart Cities.

- **Education and training**

  In order to ensure and provide an adequately trained and adaptive workforce, common standards are required for distance learning tools that can be developed, deployed, and used at short notice in any arbitrary setting including so-called adaptive learning spaces, whether permanent or transient.

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- **Emergency planning and response**

  Emergency Services Messaging (emergency service call centres, dispatch services, first responders, resource allocation)

5.4.3 Facilitating instrumentation, analysis, decision-making, and automation

- **Geospatial information**

  Geospatial information standards are a foundation to Smart Cities. Requirements include: spatial referencing by coordinate and name; web mapping and related features; location based service for tracking and navigation; linear referencing; ubiquitous public access and place identifier linking; land administration modelling; sensor modelling; and core geospatial terminology

- **Performance and other indicators**

  Identifying or developing sets of Key Performance (KPI) and other indicators to gauge the success of Smart City ICT deployments. KPIs are required to provide performance as seen from different viewpoints, such as those: of residents/citizens (reliability, availability, quality and safety of services, etc.); of community and city managers (operational efficiency, resilience, scalability, security, etc.); and of the environment (climate change, biodiversity, resource efficiency, pollution, recycling rates/returns).

  However, the indicators appropriate for one city or context may not be the same for others. As such, there should also be standardized guidance for city managers on selecting and using KPIs appropriate to their particular situation.

  Requirements for standardized risk assessment methodologies for critical infrastructure dependencies across organisations and sectors.

5.4.4 Responding to societal challenges

All cities strive to improve the quality of life for their citizens and residents. The increased complexity of Smart Cities present new challenges and opportunities through the use of ICT. Cities have traditionally been equated with the anonymity of the individual, whether that is embraced or feared often depended on the person. The prevalence of mobile phones and other devices together with real-time location based services now mean that cities are decreasingly a place for anonymity.

Cities also represent a scale of social organization that make decision-making ‘en masse’ highly impractical with the result that complex levels of representative government and governance have emerged over time. ICT eliminates many of the physical limitations of mass decision-making while also eliminating many of the social aspects of face-to-face discourse and interaction.

- **Scenario-building and participative decision-making**

  This is another situation where a Smart City Framework can provide a valuable set of tools.

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- **Privacy and information sharing**

  ICT provides increasingly sophisticated means by which individuals can manage aspects of personal privacy within particular social and legal norms.

  Development of Privacy Impact Assessments, identification of data flows using or impacting on personal information

- **Environment**

  Data exchange between Enterprise Resource Planning (ERP) systems and environmental information systems, such as air quality, waste management and treatment, etc.

  Smart Water Management (SWM) in cities seeks to alleviate challenges in the urban water management and water sector through the incorporation of Information and Communication Technologies (ICTs) products, solution and systems in areas of water management and sanitation.

  Improve the capacity of Smart Cities to respond to challenges posed by climate change Communications between safety equipment/systems.

  Interoperability between building information and communications systems

6 Technology and trends

The future Internet domain landscape comprises a great diversity of technology related topics involved in the implementation of Smart Cities. This section covers some of those that are most connected to the development of Smart Cities.

6.1 Ubiquitous computing

Ubiquitous computing is a concept in software engineering and computer science where computing is made to appear everywhere and anywhere. In contrast to desktop computing, ubiquitous computing can occur using any device, in any location, and in any format. A user interacts with the computer, which can exist in many different forms, including laptop computers, tablets and terminals in everyday objects such as a fridge or a pair of glasses. Ubiquitous computing is also described as pervasive computing, ambient intelligence, or “everyware”.

One particular challenge in the context of Smart Cities relates to open data business models. As services become pervasive and ubiquitous, the matter of opening up databases will become more important. Transparency towards the end users on how their information is being used, with clear opt-in options and secured environments, has to be the starting point when providing services that leverage personal data. The Public Sector Information re-use and utilisation of open data introduces a paradigm shift that will impact on many people working in public administration. Among many activities necessary for Public Sector Information provision and re-use, one can identify achieving most easy comparability and comprehensibility through furthering meta-data and data standardisation, and supporting the publishing of more fine granular data through mechanisms for automatic anonymization or pseudonymization of data sets.

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6.2 Networking

Networking is about bringing higher broadband capacity with FTTH, 4G LTE and IP Multimedia Systems (IMS) as well as future networking technologies. Networking technologies provide the infrastructure of the Smart Cities to make all the devices, computers and people can have convenient, reliable, secretive communication paths with each other.

Networking technologies will enable the democratization, in terms of reasonable cost for high quality service, of Immersive Digital Environments. Such environments enable, for example, the radical increase of telecommuters (far less people travelling in and out the city), remote diagnosis in healthcare, and web-streaming of cities' events. All these examples would contribute to reduce the level of congestion and wasted time and resources in every situation. Research areas such as Content Centric Networking (CCN) and Ubiquitous Computing are also promising faster processing that would increase the real-time capacity that is vital for mass interactions.

6.3 Open Data

The term "Open Data" in the context of Smart Cities generally refers to a public policy that requires public sector agencies and their contractors to release key sets of government data (relating to many public activities of the agency) to the public for any use, or re-use, in an easily accessible manner. In many cases, this policy encourages this data to be freely available and distributable.

The value of releasing such data is presumed to lie in the combination of this and other data from various sources. For example, GPS data when combined with a mapping system can provide an abundance of location services.

This value can be dramatically increased when the data is discoverable, actionable and available in standard formats for machine readability. The data is then usable by other public agencies, third parties and the general public for new services, and for ever richer insight into the performance of key areas like transport, energy, health and environment. This insight comes from applying ever more powerful analytics to the data.

Data is the lifeblood of a Smart City and its availability, use, cost, quality, analysis and associated business models and governance are all areas of interest for all actors within the city. We therefore need to ensure that any standards or guidance in this area should not be prescriptive about particular models, but encourage innovation in data re-use.

6.4 Big Data

Big data is a blanket term for any collection of data sets so large, complex and rapidly changing that it becomes difficult to process using traditional database management tools or traditional data processing applications. Managed and analysed well, the data can be used to unlock new sources of economic value, provide fresh insights into science and hold governments to account. However, traditional data processing approaches cannot process such a vast amount of information. The challenges include capture, curation, storage, search, sharing, transfer, analysis and visualization.

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Big data techniques are developed to deal with these issues and make it possible to do many things that previously could not be done easily: "spot business trends, determine quality of research, prevent diseases, link legal citations, combat crime, and determine real-time roadway traffic conditions"[3]. These insights rely on rapidly evolving analytics techniques which support analysis distributed across one or more data sources. Predictive capability can be provided by applying Machine Learning to the data.

A Smart City, as a "system of systems", can potentially generate vast amounts of data, especially as cities install more sensors, gain access to data from sources such as mobile devices, and government and other agencies make more data accessible. Consequently, Big Data techniques and concepts are highly relevant to the future of Smart Cities.

The Big Data Report (available at www.jtc1.org) provides a comprehensive summary of Big Data and its implications.

6.5 GIS (Geographic Information System)

A geographic information system (GIS) is a computer system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. GIS is a relatively broad term that can refer to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business.

In Smart Cities, GIS is used to provide location based services. The implementation of a GIS in Smart City is often driven by city jurisdictional, purpose, or application requirements. GIS and location intelligence applications can be the foundation for many location-enabled services that rely on analysis, visualization and dissemination of results for collaborative decision making. GIS provides a technologically strong platform to every kind of location based business personals to update data geographically without wasting time to visit the field and update in database manually. For that reason, GIS applications are tools that allow city managers and citizens to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.

6.6 Cloud computing

Cloud computing is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet). Clouds can be classified as public, private or hybrid.

Cloud computing is increasingly helping the private sector to reduce cost, increase efficiency, and work smarter. From a business perspective, cloud computing is a key concept to enable a global ecosystem, where organisations are able to be more competitive. In the context of this ever-increasing complexity and platformisation, interoperability between systems will be exceedingly important. Standardisation is clearly an important task, affecting all levels of middleware implementation, assuring

3) "Data, data everywhere"<http://www.economist.com/node/15557443>. The Economist. 25 February 2010. Retrieved 9 December 2012.

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transparent and reliable interfaces to the middleware, as well as interoperability between products and services across very different domains. Thus, interoperability and standardised ways of communication between systems is an important research subject, crosscutting all Smart City domains.

6.7 Service-Oriented Architecture (SOA)

Service-oriented architecture (SOA) is a software design and software architecture design pattern based on distinct pieces of software providing application functionality as services to other applications. This is known as service-orientation. It is independent of any vendor, product or technology.

Pre-built integration into back-office applications and multi-channel access to maximize citizen self-service results in higher efficiencies and cost savings, and must be implemented with a SOA that facilitates a fully shared environment. Taking a SOA approach for local and city government organizations will require a new way of thinking about IT infrastructure, not only technically but organizationally. SOA can leverage a world of multiple vendors that build systems, which create interoperability and use each other's capabilities. By interoperating and mapping an SOA approach across IT systems, local governments can achieve dramatic results. This shifts the old IT model of proprietary systems that cannot be transformed from older generations of technology to a flexible, shared model that leaves room for scalable, incremental growth. With flexibility for the future, government organizations are no longer beholden to legacy systems or partners that promote them, nor are they faced with a step-function such as the need to remove large data systems all at once.

6.8 E-government

E-government (short for electronic government, also known as e-gov, Internet government, digital government, online government, or connected government) consists of the digital interactions between a government and citizens (G2C), government and businesses/commerce (G2B), government and employees (G2E), between government and governments /agencies (G2G), as well as citizen interaction with their government (C2G). The E-Government essentially refers to the utilization of Information Technology (IT), Information and Communication Technologies (ICTs), and other web-based telecommunication technologies to improve and/or enhance on the efficiency and effectiveness of service delivery in the public sector. The e-Government promotes and improves broad stakeholders contribution to national and community development, as well as deepen the governance process.

The development of efficient and effective e-government is a prerequisite for the development of Smart Cities. The lack of horizontal and vertical integration across the various e-government and urban initiatives, and the relatively low level of interest shown by many national authorities, limit efforts for the systemic development and implementation of local e-government. The development of transnational authentication systems for citizens and businesses, the development of agreed frameworks for data privacy, and the sharing and collection of individual and business data, are key. Standardisation and interoperability are key requirements for the widespread adoption of technologies and services to provide e-government at the city level. Cities will need to be able to better integrate wireless networks, making provision seamless and

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transparent. Cities will increasingly move from being service providers to platform ones, providing an infrastructure that enables the development of a broad range of public and private applications and services. Standardised technologies and infrastructures that are necessary to provide personalised and location-based services need to be developed.

6.9 Embedded networks

An embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. By contrast, a general-purpose computer, such as a personal computer (PC), is designed to be flexible and to meet a wide range of end-user needs. Embedded systems control many devices in common use today.

Embedded networks of sensors and devices into the physical space of cities are expected advancing further the capabilities created by web 2.0 applications, social media and crowdsourcing. A real-time spatial intelligence is emerging having a direct impact on the services cities offer to their citizens. Collective intelligence and social media has been a major driver of spatial intelligence of cities. Social media have offered the technology layer for organizing collective intelligence with crowdsourcing platforms, mashups, web-collaboration, and other means of collaborative problem-solving. Now, the turn to embedded systems highlight another route of spatial intelligence based on location accurate and real-time information. Smart Cities with instrumentation and interconnection of mobile devices and sensors can collect and analyse data and improve the ability to forecast and manage urban flows, thus push city intelligence forward.

6.10 Internet of Things (IoT)

The Internet of Things (IoT) refers to the interconnection of uniquely identifiable embedded computing like devices within the existing Internet infrastructure. Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a Smart Grid.

Internet of Things including sensor networks and RFID is an important emerging strand. These technologies overcome the fragmented market and island solutions of Smart Cities applications and provide generic solutions to all cities. Examples of generic architecture include networked RFID tags (passive and active tags, mobile devices), sensor networks (multimodal sensors and actuators, built-in intelligent agents), and connected objects such as distributed intelligent systems, intelligent objects and biometrics. A new round of applications, such as location aware applications, speech recognition, Internet micro payment systems, and mobile application stores, which are close to mainstream market adoption, may offer a wide range of services on embedded system into the physical space of cities. Augmented reality is also a hot topic in the sphere mobile devices and smart phones, enabling a next generation location-aware applications and services.

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7 Standards relevant to Smart Cities

7.1 The roles of the different standards bodies

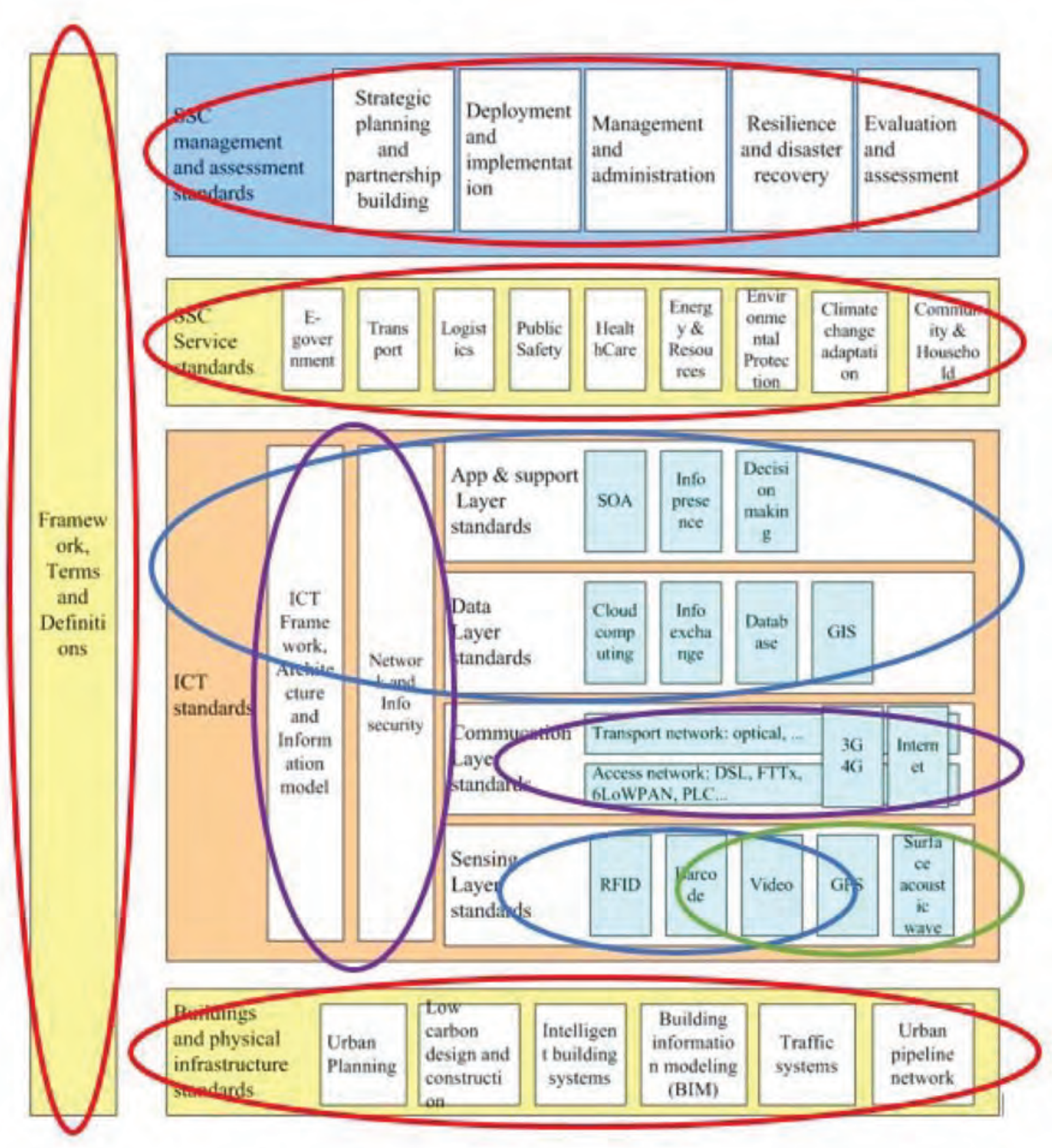

Figure 4 — Smart City standards model

We suggest the following diagram may position JTC 1 contributions with regard to the other international organizations. The diagram is modified from a ITU-T technical report contributed to the Study Group..

In this figure, we suggest that the ellipses approximately represent the core areas of ISO (red), ISO/IEC JTC 1 (blue), ITU-T (purple) and the IEC (green).

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The application domain expertise for Smart Cities lies in ISO TCs. Thus ISO contributes to the top and bottom layers, as well as the Terms and Definitions vertical of this view.

ICT is the core of this model, positioned as an enabler. In the above model, it is clear that JTC 1 contributions are very important to enable a Smart City, with its standards already covering the Data layer and the App & support layer, as well as contributing to the sensing layer. Communications and networking are dominated by the ITU, with contribution from JTC 1/SC6 while security is heavily contributed to by JTC 1/SC27.

It is important to be clear that this diagram is a highly simplified one and that there are many areas of overlap – for instance the IEC work on smart grid would fit into the service layer under Energy and Resources.

7.2 Smart City standards work going on in other standards bodies

Specific Smart City standardization working items are being developed by a variety of both new and well-established SDOs/consortia outside of ISO/IEC JTC 1. The standards work includes both detailed standards on specific issues that are fundamental to the implementation of Smart Cities, as well as work on Smart City standards as such.

These areas of standards clearly are much wider than just ICT. It is important for JTC 1 to take account of all of these initiatives as they set the context of the standards work of relevance to JTC 1. It is also likely that there may well be an ICT element of some of the standards work being carried out by other standards bodies.

The following table gives an overview of the major standardization initiatives, national or regional strategy, and commercial solutions on Smart Cities.

Table 1 — Smart Cities related standardization initiatives and activities outside ISO

Title	Related fields and corresponding work to Smart Cities
1. ITU-T	ITU-T Study Group 5 – Environment and climate change – Focus Group on Smart Sustainable Cities, aims to act as an open platform for smart-city stakeholders – such as municipalities; academic and research institutes; non-governmental organizations (NGOs); and ICT organizations, industry forums and consortia – to exchange knowledge in the interests of identifying the standardized frameworks needed to support the integration of ICT services in Smart Cities. "Smart Sustainable Cities'' is also the theme of ITU's 3rd Green ICT Application Challenge. Specifically the Study group is developing SSC-0110, a Technical Report on Standardization Activities and Gaps for SSC, which aims to provide a framework for all standards work on Smart and Sustainable Cities and set potential work for ITU-T within that. There are a number of other Technical Reports being developed that would be of relevance to JCT1 activities.

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Title	Related fields and corresponding work to Smart Cities
2. IEC	In June 2013 IEC agreed the establishment of a Systems Evaluation Group (SEG) on Smart Cities to consider a Smart City as a system of systems and to review whether IEC should set up a Systems Committee to oversee standards in this area. The first plenary was in December 2013 and the final report will be presented to IEC in June 2015. The role of the SEG is to identify standardization areas that : - need a Systems approach - address Cities relevant cross-cutting issues. - are within the scope of IEC i.e. in the electro-technical field. In addition IEC/SMB/SG3 Strategic Group on Smart Grid has developed a number of standards of relevance to Smart Cities: 1. IEC/TR 62357:2003 Power system control and associated communications - Reference architecture for object models, services and protocols 2. IEC 61850 Power Utility Automation 3. IEC 61970 Common Information Model (CIM) / Energy Management 4. IEC 61968 Common Information Model (CIM) / Distribution Management 5. IEC 62351 Security 6. IEC PC118

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Title	Related fields and corresponding work to Smart Cities
3. IEEE Standards Association	IEEE has been working for many years on the infrastructure, networking, generation, automation, operation, and distribution necessary to design, support, deliver, and connect new energy to the cities and homes that demand it. The resulting active standards and standards projects for Smart Cities number over 150 and are categorized into the topics of Smart Grids, Internet of Things (IoT), eHealth, Intelligent Transportation Systems (ITS), and other related topics. Key components include: **Smart Interoperability:** The IEEE 2030 series is based on a Smart Grid interoperability reference model (SGIRM) and provides alternative approaches and best practices for Smart Grid work worldwide. It defines terminology, characteristics, functional performance, evaluation criteria and the application of system engineering principles for Smart Grid interoperability with end-use applications and loads. IEEE P2030.1 addresses applications for road-based personal and mass transportation. IEEE P2030.2 provides guidelines for discrete and hybrid energy storage systems that are integrated with the electric power infrastructure, including end-use applications and loads. IEEE P2030.3 establishes test procedures for electric energy storage equipment and systems for electric power systems (EPS) applications. **Smart Grid Networks**: A number of IEEE standards address high performance and high communication reliability and efficiency, including IEEE 1901. The IEEE 1901 inter-system protocol (ISP) enables coexistence of Broadband Power Line systems operating on the same power lines. IEEE P1901.2 enables real time communication between the electric meter and the utility operations center. This is the key element of making the grid smarter, enabling every home to become a true element of the Smart Grid where consumers have an opportunity of being actors actively involved in managing the Smart Grid. Additional standards and projects cover a broad range of fields, including: • Networking and Communications, including the Home • Cyber Security • Substations Automation • Renewables • Power Quality and Energy Efficiency • Intelligent Transportation Systems
4. European Commission	1. By launching a Smart Cities and Communities European Innovation Partnership (SCC) the European Commission aims to boost the development of smart technologies in cities – by pooling research resources from energy, transport and ICT and concentrating them on a small number of demonstration projects which will be implemented in partnership with cities. For 2013 alone, € 365 million in EU funds was earmarked for the demonstration of these types of urban technology solutions. Standardisation is one of the 11 areas of work that is being undertaken. 2. EU's Seventh Framework Programme for Research(FP7) will invest €4.8 billion in thematic areas, with specific priorities to preserve oceans and water, better use of raw materials, efficient energy, promote efficiency in the processing of biological resources, develop Smart Cities and tackle issues such as public sector reform, brain research and anti-microbial resistance. 3. European Smart Cities Ranking

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Title	Related fields and corresponding work to Smart Cities
5. CEN/ CENELEC and ETSI	CEN/CENELEC and ETSI have set up a Coordination Group to cover the area of standardisation work for Smart and Sustainable Cities and Communities the report will be completed by October 2014. The European Innovation Partnership on Smart Cities and Communities has acknowledged the key role of the Coordination Group in the development of European standards relating to Smart Cities and have set up an action cluster on standards and indicators for Smart Cities and Communities to encourage wide participation in this work.
6. NIST	Framework and Roadmap for Smart Grid Interoperability
7. ANSI	On April 4, 2013, the American National Standards Institute (ANSI) convened a Joint Member Forum with subject matter experts from standards developing organizations, industry, government, and academia to discuss the role that standards and conformance solutions can play in contributing to national and international Smart City initiatives.
8. BSI	The UK Department of Business, Innovation and Skills commissioned BSI to develop a standards strategy for Smart Cities. This strategy aims to accelerate the implementation of Smart Cities and minimize the risks of failure in April 2012. The strategy outlines a foundation of knowledge to help cities as the embark on a programme to become smarter: 1. BSI PAS 180 Smart Cities – Vocabulary 2. BSI PAS 181 Smart City framework – Guide to establishing strategies for smart cities and communities 3. BSI PAS 182 Smart City Data Concept Model 4. BSI PD 8100 on Smart City Overview – a guide for city managers 5. BSI PD 8101 Smart cities – Guide to the role of the planning and development process 6. BS 8904 Guidance for community sustainable development provides a decision-making framework that will help setting objectives in response to the needs and aspirations of city stakeholders 7. BS 11000 Collaborative relationship management
9. ACR NEMA	Digital Imaging and Communication of Medicine
10. China	In China, several national standardization committees and consortia have started standardization work on Smart Cities, including China National IT Standardization TC (NITS), China National CT Standardization TC, China National Intelligent Transportation System Standardization TC, China National TC on Digital Technique of Intelligent Building and Residence Community of Standardization Administration, China Strategic Alliance of Smart City Industrial Technology Innovation. NITS is the mirror committee of JTC 1 in China. The progress on Smart Cities are: 1. Investigation Report on Status of Smart Cities and Standard Needs in China 2. Draft Research Report on China Standard System on Smart Cities 3. Started studying on several standard items on Smart Cities, such as terminology, reference model, evaluation model and basic indexes, data and services fusion, methodology for planning and designing based on EA, guidance on how to use current SOA standards 4. A book - Implementation Guidance for Smart Cities

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Title	Related fields and corresponding work to Smart Cities
11. Korea	Standardization of ICT infrastructure, processes and governance norms will lead to the creation of an extensive information-led ecosystem which can deliver uniform citizen and business services. A symbiotic collaboration model of ownership and accountability across government and private institutions will be crucial. Going forward, U-City projects will have an intrinsic lifecycle management process aligned to changing business and citizen requirements, thereby driving sustained competitive edge.
12. Germany	Member of European Innovation Partnership (EIP) for Smart Cities and Communities. DKE and DIN have developed a joint roadmap and Smart Cities recommendations for action in Germany.

The following table on Smart Cities provides an overview of the major concerns of cities today and how ISO standards provide support for better, healthier and safer city living. It highlights how International Standards contribute to building Smart Cities by improving energy efficiency, increasing safety, planning sustainable urban development, developing reliable road networks and effective means of transportation, reducing pollution and dealing with water and wastewater management.

Table 2 — ISO standardization work on Smart Cities

TC No.	Related fields and corresponding work to Smart Cities
1. ISO/TC 268	TC 268, Sustainable development in communities, focuses on the development of a management system standard. ISO/TC 268/ SC 1, Smart community infrastructures, is dedicated to smart urban infrastructures. 1. ISO 37101, *Sustainable development and resilience of communities – Management systems–General principles and requirements* 2. ISO 37120, *Sustainable development and resilience of communities – Global city indicators for city services and quality of life* 3. ISO/TR 37150, *a technical report on smart urban infrastructures around the world* 4. ISO 37151 standard on harmonized metrics for benchmarking smartness of infrastructures
2. ISO/TC 163 and ISO/TC 205	A joint working group (JWG) helps coordinate common areas between ISO/TC 205, *Building environment design*, and ISO/TC 163, *Thermal performance and energy use in the built environment,* and has developed a holistic approach to address buildings' energy performance. The JWG has started work on a standard for addressing the indoor environmental conditions assumed in energy performance calculations. 1. ISO 16346, *Energy performance of buildings – Assessment of overall energy performance* 2. ISO 16343, *Energy performance of buildings – Methods for expressing energy performance and for energy certification of buildings* 3. ISO 12655, *Energy performance of buildings – Presentation of measured energy use of buildings* 4. ISO/TR 16344:2012, *Energy performance of buildings – Common terms, definitions and symbols for the overall energy performance rating and certification* 5. ISO 13153:2012, *Framework of the design process for energy saving single-family residential and small commercial buildings*

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TC No.	Related fields and corresponding work to Smart Cities
3. ISO/TC 257	ISO/TC 257, *General technical rules for determination of energy savings in renovation projects*, *industrial enterprises and regions,* has a key role to play in cutting global energy consumption. Energy savings and the resulting improved energy efficiency are the best ways to restrain energy consumption and reduce greenhouse gas (GHG) emissions. Measurement, calculation and verification have established themselves as the cornerstone to stimulate technologies and policies and encourage efficiency. To enhance collaboration in related technical subjects at an organizational level, an ISO/TC 242, Energy management (leading body)-ISO/TC 257 joint working group (JWG) for the Measurement and verification of organizational energy performance – General principles and guidelines, has also been established.
4. ISO/TC 242	ISO/TC 242, *Energy management*, focuses on the field of energy management, including for example: energy efficiency, energy performance, energy supply, procurement practices for energy using equipment and systems, and energy use as well as measurement of current energy usage, implementation of a measurement system to document, report, and validate continual improvement in the area of energy management. 1. ISO 50001:2011, *Energy management systems – Requirements with guidance for use*.
5. ISO/TC 59	ISO/TC 59, *Buildings and civil engineering works*, subcommittee SC 14, *Design life*, focuses on balancing environmental and economic impacts, applying the overall methodology of service life planning to open source data transfer. 1. ISO 15686, *Buildings and constructed assets – Service life planning* 2. ISO 16739, *Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries*
6. ISO/TC 223	ISO/TC 223, *Social Security*, develops standards for public and private organizations in such areas as: resilience, exercises, public/private partnership, emergency management, capability assessment, mass evacuation, and continuity management. 1. ISO 22316, *Societal security – Organizational resilience – Principles and guideline* 2. ISO 22301:2012, *Societal security – Business continuity management systems – Requirements* 3. ISO 22313:2012, *Societal security – Business continuity management systems – Guidance* 4. ISO 22398, *Societal security – Guidelines for exercises*, helps businesses to plan and carry out joint exercises and test their preparations, ability and capacity to deal with unexpected events. *5.* ISO 22320:2011, *Societal security – Emergency management – Requirements for incident response* 6. ISO 22324, *Societal security – Emergency management – Colour-coded alert*
7. ISO/TC 241	ISO/TC 241, *Road traffic safety management systems*, covers the field of RTS, Road traffic safety. ISO 39001 will assist governmental and private sector organizations alike by providing a structured, holistic approach to road traffic safety as a complement to existing programmes and regulations. 1. ISO 39001:2012, Road traffic safety (RTS) management systems – Requirements with guidance for use

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TC No.	Related fields and corresponding work to Smart Cities
8. ISO/TC 204	ISO/TC 204, *Intelligent transport systems*, focuses on standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services in the intelligent transport systems (ITS) field.
9. ISO/TC TMB	ISO/TC Technical Management Board 1. ISO 20121:2012, *Event sustainability management systems – Requirements with guidance for use*, specifies requirements for an event sustainability management system for any type of event or event-related activity, and provides guidance on conforming to those requirements. It has been developed to help ensure that events, ranging from local celebrations to “ mega events ” such as the Olympic and Paralympic Games, leave behind a positive legacy in terms of economic, environmental and social benefits, with minimum material waste, energy consumption, or strain on local communities. 2. ISO 26000:2010 *guidance on social responsibility (SR)* is intended to provide organizations with guidance concerning social responsibility and can be used as part of public policy activities. In addition, the ISO TMB has set up a Strategic Advisory Group on Smart Cities, which had its first meeting in June 2014. This aims to: • propose a clear working definition of Smart Cities; • describe the Smart Cities landscape and identify the aspects of the Smart City concept that are most relevant to ISO; • review the existing initiatives and standards activity in ISO; • develop a gap analysis to identify areas for standards development in ISO and areas for collaboration with other standards bodies, and • coordinate ISO input, and nominate experts, to the IEC/SEG1 It has engaged with the leadership of the IEC/SEG1, the ITU-T SG5 Focus Group on Smart Cities, the ISO/IEC JTC 1/SG1 on Smart City and CEN-CENELEC-ETSI SSCC-CG, in order to help avoid duplication of efforts on international standards activity on Smart Cities.

7.3 Standards work relevant to Smart Cities going on elsewhere in JTC 1

There is already a great deal of work being undertaken within JTC 1 of relevance to Smart Cities. Below is a matrix which attempts to show the key technologies that underpin many Smart City initiatives and the relevant Sub Committee or Working Group that is dealing with that area.

In the matrix, the capital Xs indicate the group that is leading in that area, and the small xs indicate other groups that are doing relevant work.

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SG Smart City IT and JTC 1 Systems Integration Matrix

Version 0.3, 2014-09-15

	Governance and Management	Engineering	Security	Sensors	Actuators	Tags	Networking	Middleware	Clouds	Data and Ontologies	Big Data	GIS	Cloud Computing	SOA	Internet of Things	Analytics Applications	Transactional Applications	Collaborative Applications	Control Applications
SC 02 Coding																			
SC 06 Network							X				x				x				
SC 07 Sw&Sys		X									x		x	x	x	x	x	x	x
SC 17 Cards ID																			
SC 22 Prog. Lang																			
SC 23 Disk																			
SC 24 Graphic										x		x							
SC 25 Interc.							x												
SC 27 Security			X										x						
SC 28 Office Eq.																			
SC 29 Multimed.											x								
SC 31 Data Cap						X											x		
SC 32 Data int.										X	x				x				
SC 34 Doc.																			
SC 35 User Int.																			
SC 36 Learn																		x	
SC 37 Bio			X																
SC 38 Middl		x						X	X				X	X	x				
SC 39 IT Sust.	x	x																	
SC 40 Gov & M	X	x							x										
SWG 2 Acc													x						
SWG 5 IOT				x	X	x	x				x	x			X		x		x
WG 7 Sensor Ntw				X			x				x				x				
SG Big Data											X	x	x			X			

Figure 5 — SG Smart City IT and JTC 1 systems integration matrix

8 Gap analysis of relevant standards

In considering the work needed to develop Smart City standards, it is important to take two key issues into consideration:

- As has been indicated, a number of other standards bodies are working to scope out and develop Smart City standards;
- As indicated above JTC 1 is already developing standards in many of the key technology areas related to Smart Cities. However, some of those standards may not necessarily reflect the complexity of dealing with a Smart City as a system of systems, and the specific challenges that this brings.

These two factors indicate the following challenges regarding Smart City standards that JTC 1 needs to address:

- The need to have a common conceptual model of the city as a system of systems. This would provide a common framework to support collaboration, both between different stakeholders in the city and different standards bodies;
- The need for the city to be able to manage issues such as privacy, security, resilience, data flows and so on, at a whole-system level;
- The need for the city to be able to evaluate how well they are using ICT to support the overall progress of their city in becoming smarter;

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- The need to ensure interoperability between different city systems;
- The help that non-specialist city leadership need in order to understand the many, complex and interrelating ICT issues relating to the move towards a smarter city and with how to put together the right portfolio of standards requirements to ensure that their projects are able to succeed;
- The need to ensure that standards being developed by SCs, WGs etc., within JTC 1 take into account the requirements of cities in their progress towards becoming smarter. Specifically, that relevant standards take into account the challenges of complex organisational requirements, including interfaces between public sector and commercial organisations; and
- The need to ensure consistency with Smart City standards being developed by other international standards bodies.

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Annex A

Smart City models

A.1 Introduction

	City History and characteristics What is the city story, its "brand" and values? Is it a stand-alone city, a hub city or satellite city? What is the size of population? Is it growing, stable or shrinking? What is its demographic mix?	
Environmental context How flat or hilly On what kind of rock it is built If it is by the sea or inland Climate	**City actors** Local authority, Health trusts, electricity and gas suppliers, police, bus and tram companies, voluntary groups, businesses, banks, investors, education providers, social care providers, and, most important of all, the citizen. **Activities** Planning, managing, purchasing, regulating, building and repairing, providing services, generating profit, gaining finance ... **Community facilities and buildings** Homes, hospitals, schools, electricity substations, sports facilities, cinemas, water treatment plants, district heating plants, factories, offices, shops ... **Infrastructures** Gas, electricity, water, sewerage, telecoms, roads and rail, district heating systems ... **Soft Infrastructures** Business / Science / Community / Innovation networks and collaboration structures **Technical systems** Traffic light management, ticketing, billing and payment, automatic number plate recognition ... **City functions or service areas** Employment, Housing, Education, Health, Security, Mobility, Energy, Water, Waste Management, Food Supply chain, Consumer Goods Supply Chain .. **Scale** Citizen, building, block, neighbourhood, district, city, metropolis ...	**Societal context** Laws & regulations Division of power between national and city governments Division of power between agencies within the city Cultural norms Economic structures and situation Political context
	City Governance The task of City Governance is to ensure that all of the functions of the city are delivered effectively at all levels of scale, and are properly co-ordinated to best deliver on the city purposes. ↓ **City Purposes** The key challenges facing the city that need to be tackled and the opportunities that need to be grasped. Social, Economic, Environmental ...	

Figure A.1 — A city model

A city is, as illustrated in Figure A.1 and detailed in Annex B, a complex system that is itself a collection of systems that have and are continuously evolving and changing within a dynamic environmental and a societal context. These types of complex systems are called 'systems of systems' (ISO/IEC 15528 Systems Engineering – Systems Engineering Life-Cycle).

Smart Cities are thus, from a systems engineering perspective, an IT intensive systems of systems. They are systems of systems because they integrate multiple systems that include people, infrastructure, and process component. They are IT intensive since IT is the 'smart' glue of the Smart City.

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Given the complexity of a Smart City, it can be represented using various models and modeling techniques and formalisms. Each of these models will represent a particular view of a Smart City. A comprehensive modeling of a Smart City needs to include different views.

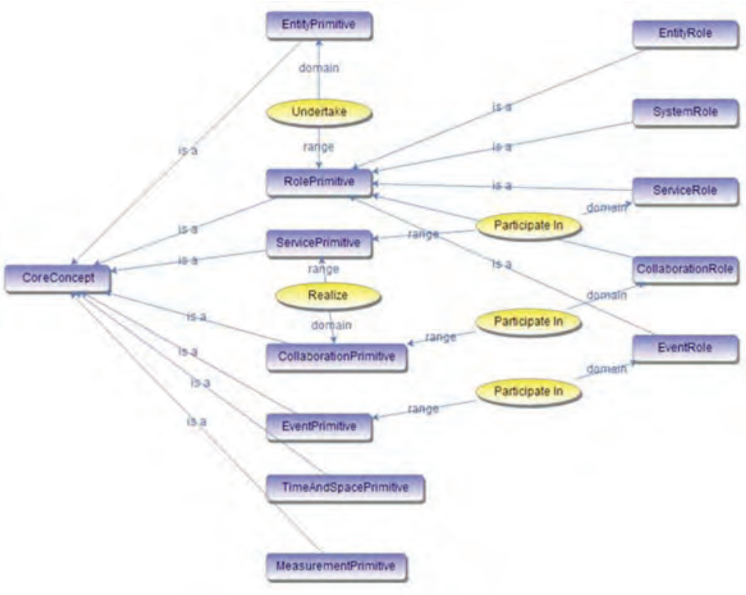

Figure A.2 — Domain knowledge model for Smart City: the Core Conceptual Model (SG N51)

As a systems of systems, a Smart City can be modelled using formalism described in JTC 1/SC7 standards such as ISO/IEC 42010 Software and Systems Engineering – Architecture description or ISO/IEC 19505 Information Technology – Object Management Group Unified Modeling Language (OMG UML). Figure A.2, the core conceptual model of the domain knowledge model of a Smart City, is using the later formalism.

The core model of Figure A.2 can then be exploded in more detailed (or finer grained) sub-models. For instance, the ServicePrimitice can be decomposed in as much as 21 categories including E-government, MarketSurveillance, PublicSafety, EmergencyManagement, LandManagement, PopulationManagement, CommunityManagement, TransportationServices, HousingPropertyManagement, EnergyManagementServices, LogisticsServices, EducationServices, CulturalServices, HealthServices, EmploymentServices, SocialSecurityServices, PensionServices, HousingSecurityServices, TourismServices, FinancialServices and E-commerce (SG N51). This model is described in more details in Annex D.

Models can also be built using a less formal representation. These models, or views, are used to convey ideas, concepts, requirements, goals, to map concepts, etc. For a complex concept such as Smart Cities, these models are also very valuable.

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A.2 Smart City models

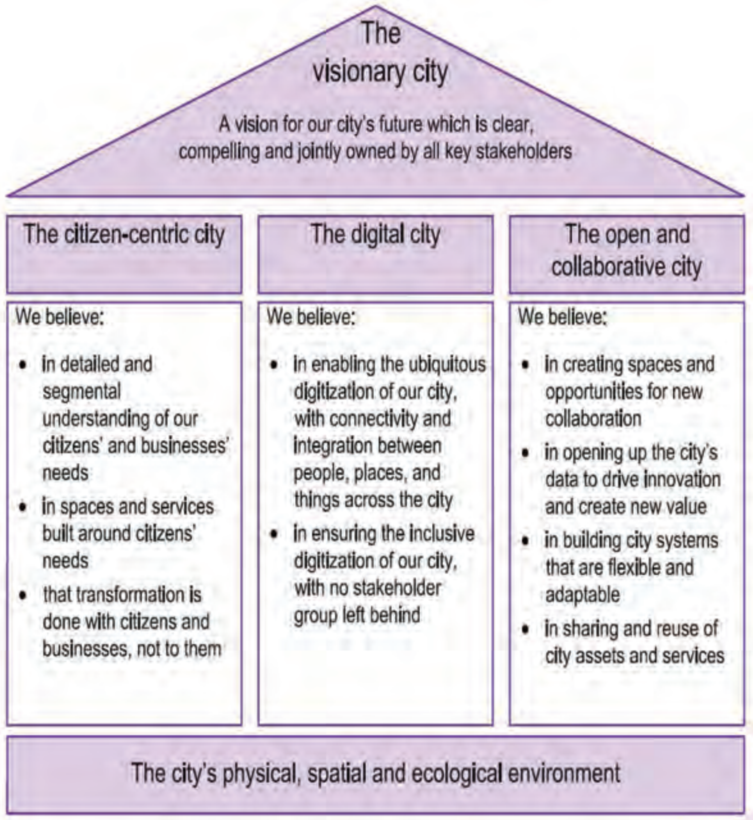

Figure A.3 — Smart City concepts and outcomes (BSI PAS 181)

A first view (Figure A.3) would put the emphasis on the concepts that characterise a Smart Cities.

As we see in Figure A.3, the physical city is collapsed in the bottom layer and three characteristics of a Smart City are expanded: citizen centric, digital and openness & collaboration. This view is well tailored to explain the characteristics of a Smart City to city administrators and governors.

Citizen-centric refers principally to the accessibility of pertinent services to citizens and business in the city. The digital city is essentially the IT enabled connectivity and integration of the different elements and services of the city. Finally, the openness & collaboration characteristic, also IT enabled, put an emphasis on the elements that drive innovation, and thus competitiveness and economic growth, in a city.

This could then be complemented by a view (Figure A.4) where the different type of systems components, structure, information and society in this cases, are presented. The ICT component of Smart Cities is already visible in this representation from the City Protocol Society.

The audience for the component model would primarily be city planners and engineers. All of the city physical environment and infrastructure is well visible in this model, as

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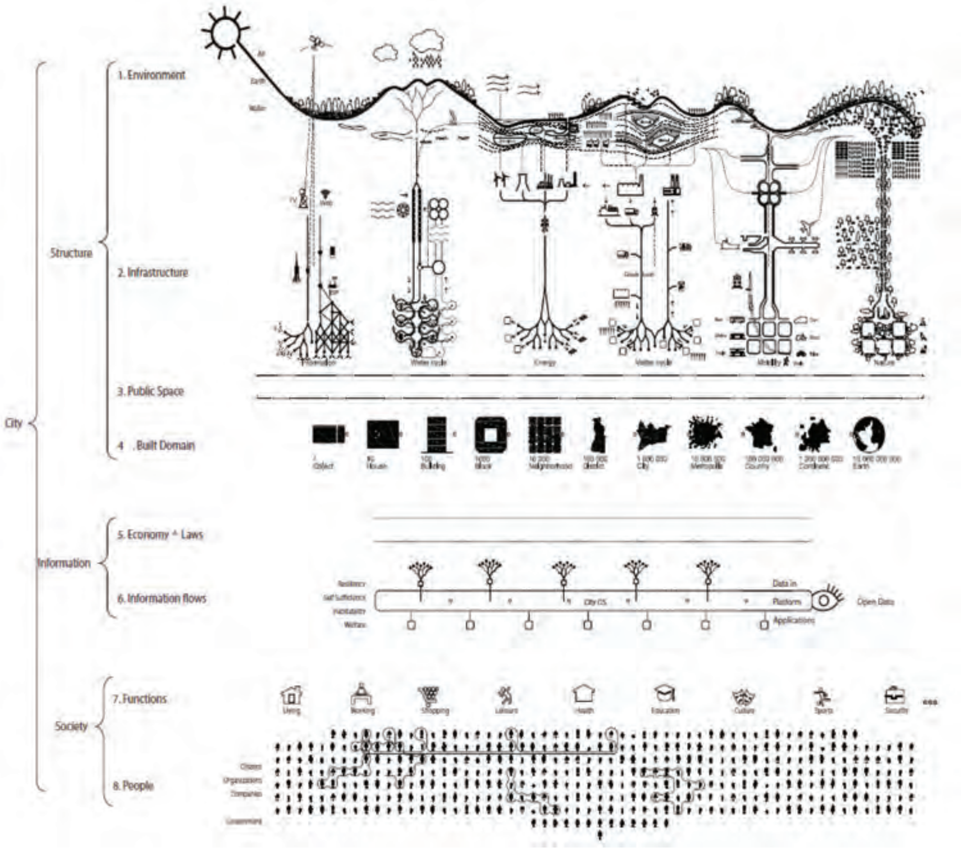

Figure A.4 — Smart Cities components (City Protocol Society)

well as the social and IT systems. This model can then be used to build an integration roadmap.

The next view (Figure A.5) that we consider has three layers: Smart Infrastructure, Smart Industry & Services and Smart Policies and Objectives. This model is more complete than the one in Figure A.3 because it is more detailed. It is also introducing the concept of sustainability, which is often associated with Smart Cities.

It is difficult not to note the emphasis on the 'Smartness' of each elements or sub-systems, although the meaning of 'Smart' in the top layer is different than for the two bottom ones.

Like the model of Figure A.3, this view is well tailored for city administrators and governors.

We can also put the emphasis in a simple model on the system integration characteristic of a Smart City (Figure A.6). Such a view not only illustrate succinctly the 'glue', or the system integration property, that ICT provides in Smart Cities, but it also makes the contributions of JTC 1 very visible.

In this view, a Smart City is presented as a combination of four Internets or networks: Internet of Data, Internet of Things, Internet of People and Internet of Services. The emphasis is thus on the system integration and synergistic characteristic of a Smart Cities.

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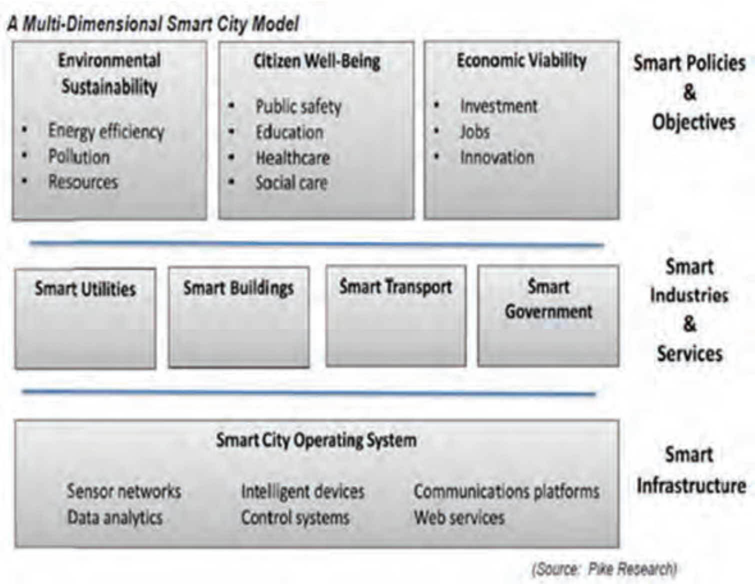

Figure A.5

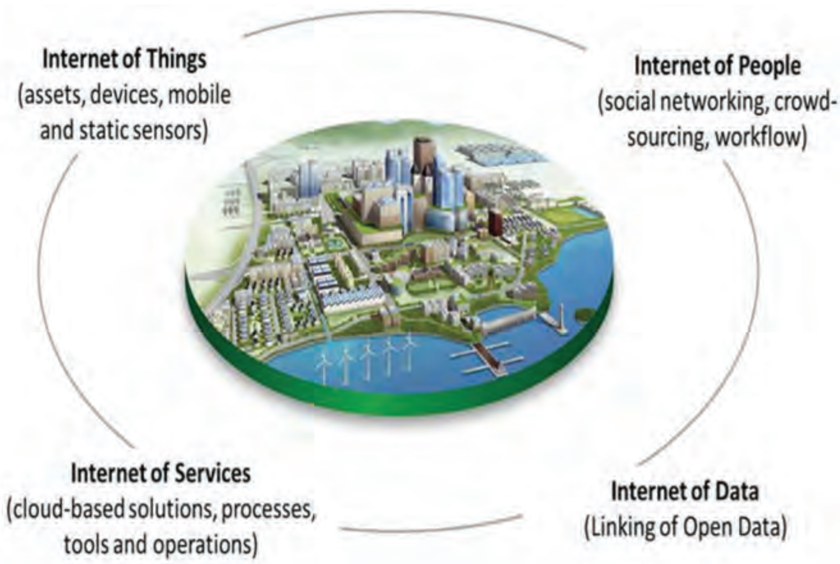

Figure A.6 — The Smart City as a set of 'Internets'

While this model is very much suited to help explain, with Figure A.3 and Figure A.5 what a Smart City is to non-specialist, standards managers should easily recognise JTC 1 contributions in Data management, service management and cloud computing, the Internet of things and networking. They should also recognise how much the 'Internet of people' is also IT enabled.

Another approach (Figure A.7) would be to emphasise in more detail than Figure A.5 the 'smartness' of the systems that are part of a Smart Cities.

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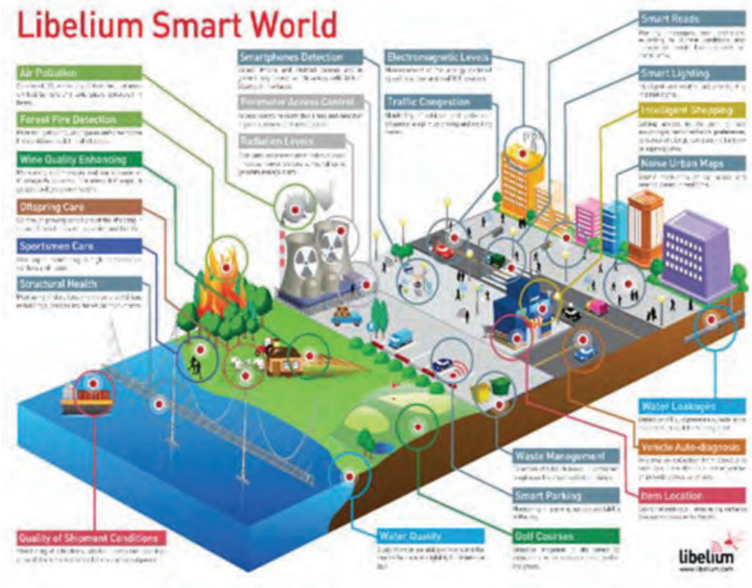

Figure A.7

While the scope of Figure A.7 is wider that a Smart City, it illustrate very clearly the wide impact to the well-being of citizen and the potential infrastructure management efficiency gain associated with a 'smarter' city environment. This model is also suited to explain what a Smart City is to a non-technical audience. While the IT component is very much visible, it is not as good as the model of Figure A.5 in making visible the pertinence of JTC 1 standards to the development of a Smart City.

The next logical step would be to model in greater detail the ICT components of Smart Cities. A type of model that is often used for ICT is a layered view. These views, inspired from the defunct OSI model, start at the bottom with the 'physical' components and can go as far as the outcomes. Figure A.8 is an example for a Smart City, with seven layers. It already make visible the ICT standards that contributes to the 'smartness' of a Smart City.

In the model of Figure A.8, the bottom layer (0) is the conventional city with its infrastructure, components (including the citizens) and processes. The environment, including the 'green' and sustainability components is at layer 1. It is important to note that, in this view, 'green' is not dependant on smartness.

Layer 2 is the interconnection layer. This is where the communications pipes are. Standards associated with this layer are coming mostly from the ITU and JTC 1 SC6.

At Layer 3 we have the instrumentation of the city. This includes sensors and the Internet of Things.

The next 3 layers are where the smartness of the Smart City is enabled. They are: Integration, Application and Innovation. In the integration layer, which is specified as 'open', we find an urban operating system, a smart grid, geospatial services, cloud computing, API's, ontologies and semantics. Contributions from SC 38 and SC 32, among others, are very visible. The application layer includes all the services, with the prefix 'i'

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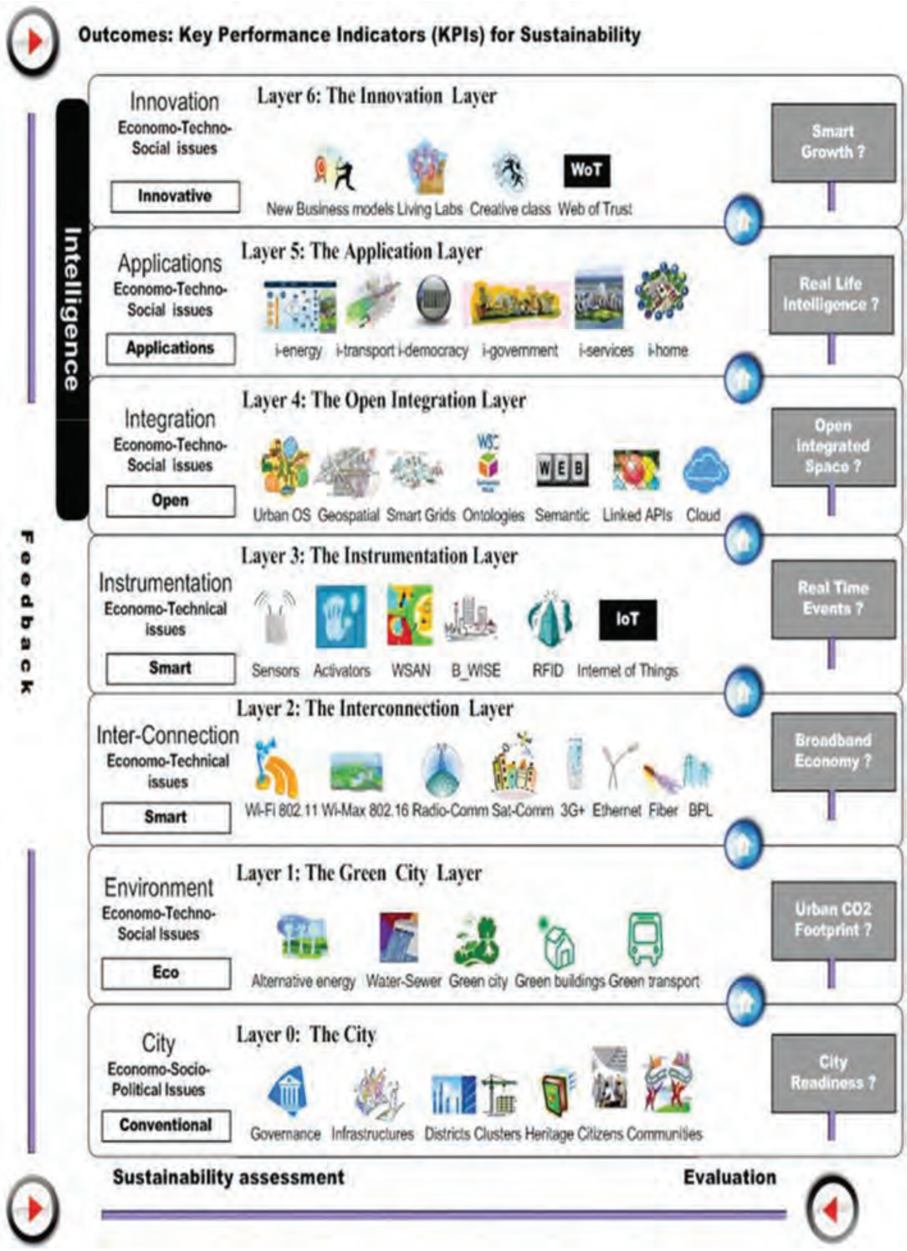

Figure A.8

used in this case. The top layer, Innovation', would be the goals and business process. It is important to note the emphasis on economic development and innovation.

Another example of a layered model is in Figure A.9. This example is based on models used to describe enterprise architecture. This shows clearly not only the ICT nature of Smart Cities, but also that a large body of knowledge in ICT Governance can be used in a Smart Cities context.

The technical model in Figure A.9 is quite classic in IT. The main differences are in the top and bottom layers: a data acquisition layer (analogous to the Internet of things in other models) has been added in the bottom and the top layer refers to the specific

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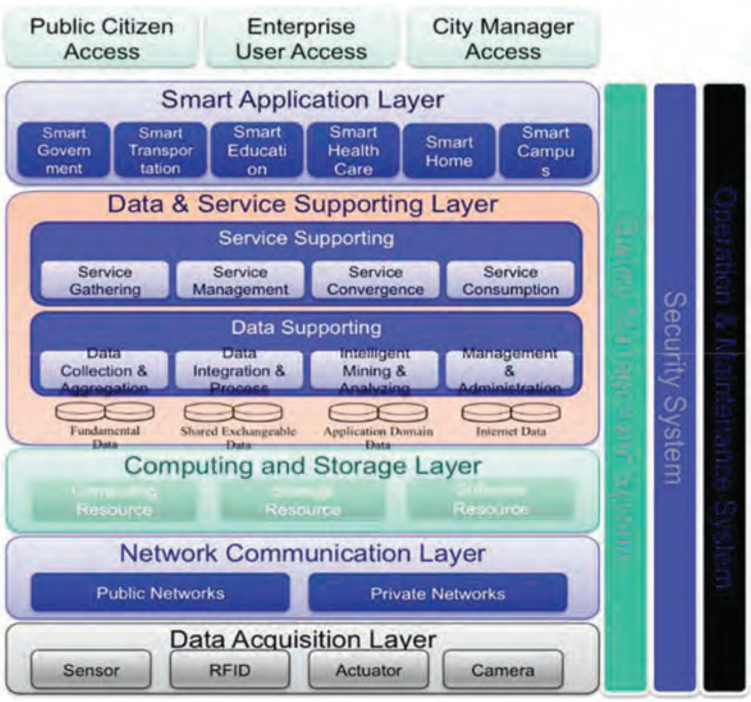

Figure A.9

business goals of a Smart City. The two verticals are also classical IT: security (SC27) and the quality management system, which will have to have a large IT Service Management (SC40) component.

Figure A.9 can be exploded to show more details, either as a more detailed 2 dimensional layer model as in Figure A.10 or a three-dimensional model as in Figure A.11.

The model of Figure A.10 is called the 'capital I-model' and is described in detail in Annex C.

In Figure A.11, the layers can be recognized in the vertical axis, and the Smart City application domain in the front horizontal axis. While such a diagram is very complete, it is difficult to read. Normally, it is shown as the top level of a series of two-dimensional views.

Another enterprise architecture view is in Figure A.12. This view, that would technically be called a business architecture, emphasise, from a domain and outcome perspective, how the

ICT in a Smart City would break value by breaking 'silos'. We see again the application of ICT governance (SC 40) in a Smart City context.

Breaking silos, bringing synergies and value through systems integration are all classical business and IT governance objectives enabled through enterprise architecture.

This re-use of ICT governance concepts is even more visible in the model of Figure A.13 where a governance view is emphasised.

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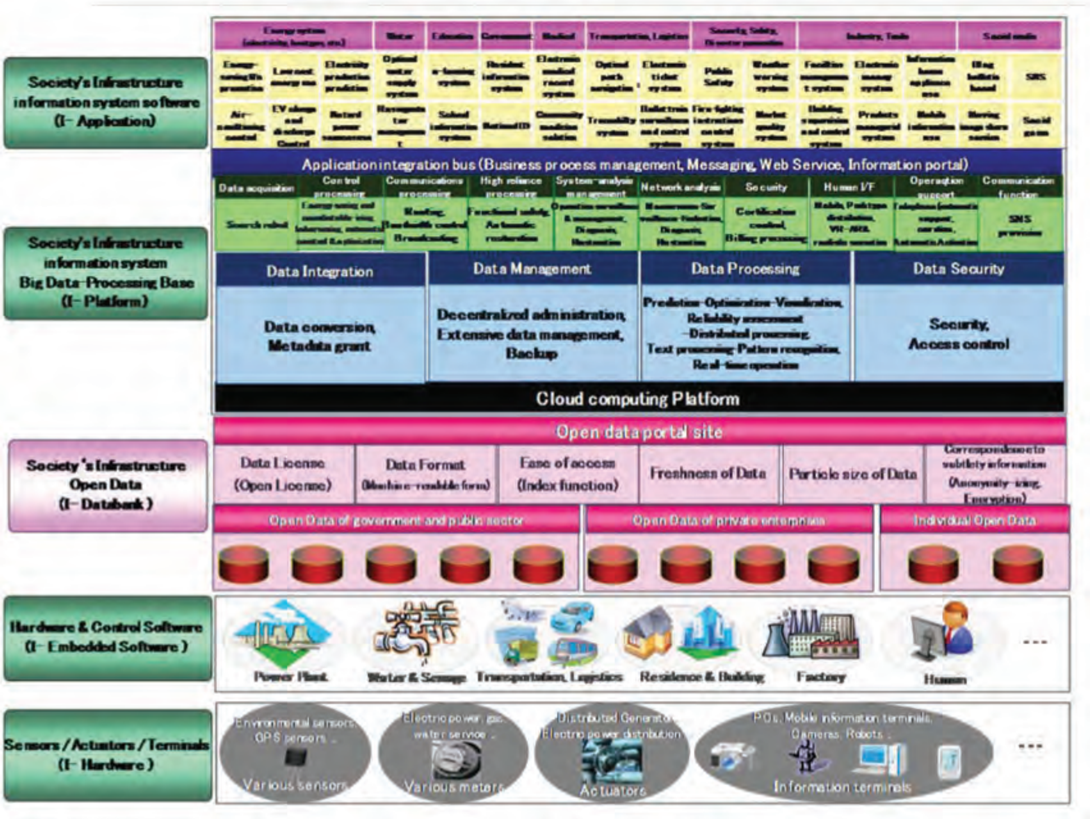

Figure A.10

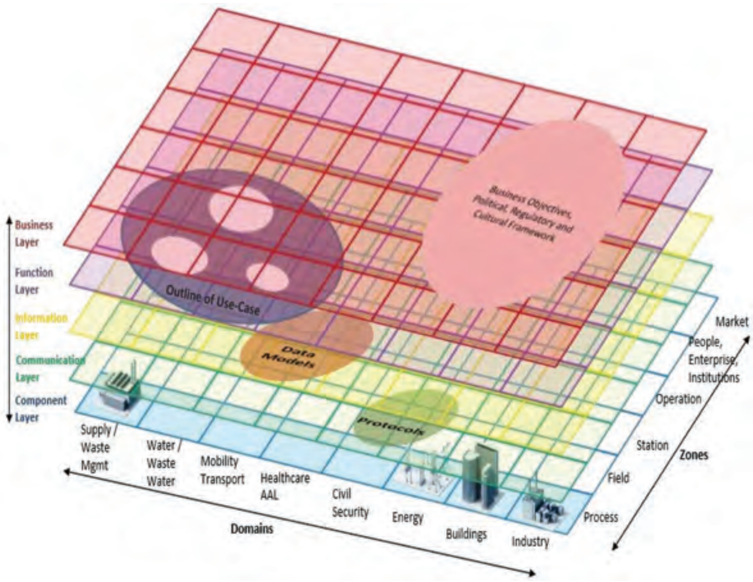

Figure A.11

The objective of the SG being to identify potential JTC 1 contributions in this area, more models than a standard focus are required.

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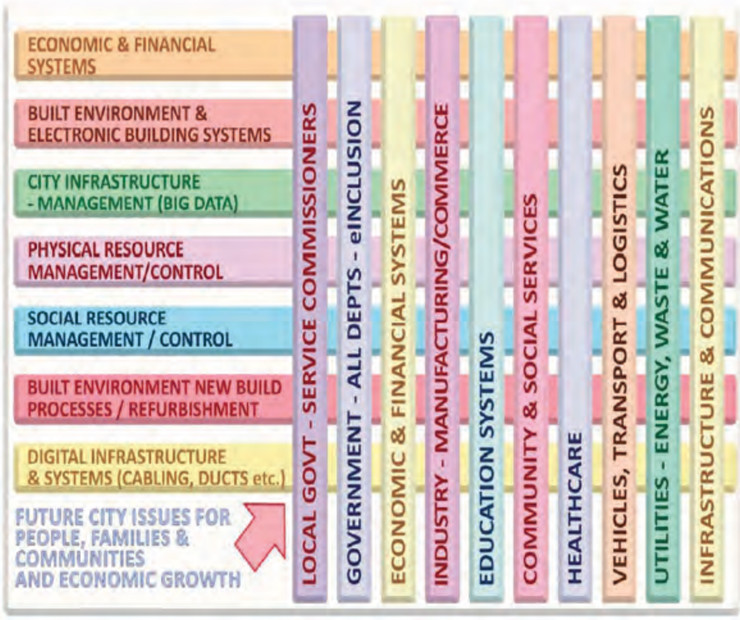

Figure A.12

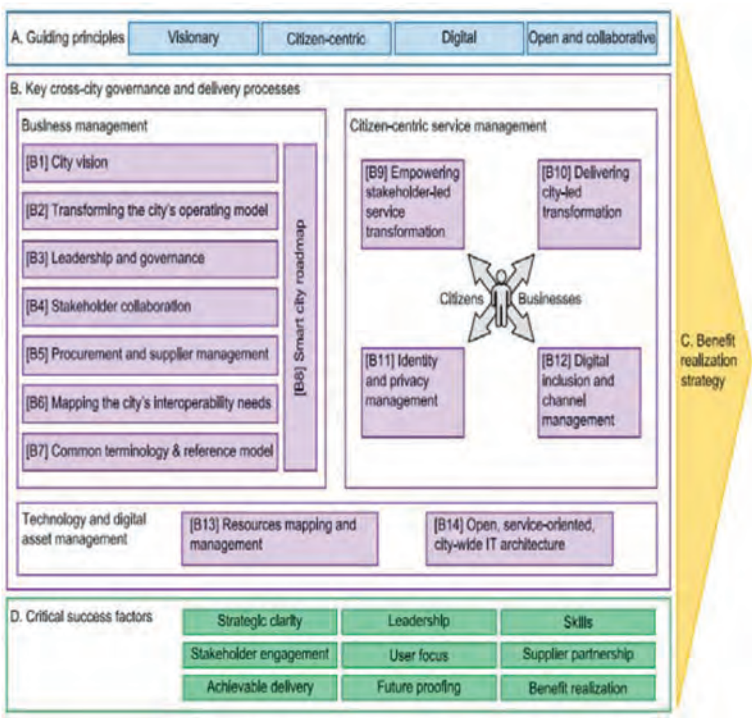

Figure A.13

One view would help position JTC 1 contributions by regard to the other 'de jure' international organisations. Figure A.14 aims to do this. It is modified from a ITU-T technical report contributed to the SG: ISO-IECJTC1-SG1_N0025_Contribution_of_Progress_of_ITU-T_FG-S.pdf. TR1/WG3 Technical Report on Standardization Activities and Gaps for SSC and suggestions to SG5.

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In this figure, the ellipses approximately represent the core areas of ISO (red), ISO/IEC JTC 1 (blue), ITU-T (purple) and the IEC (green).

The application domain expertise for Smart Cities lies in ISO TCs. Thus ISO contributions to the top and bottom layers, as well as the Terms and Definitions vertical of this view.

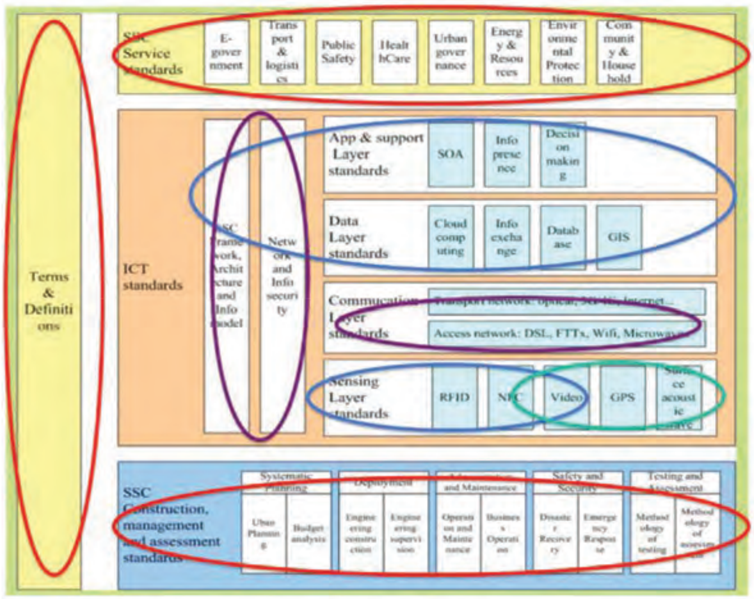

Figure A.14

ICT is the core of this model, positioned as an enabler. In the above model, it is clear that JTC 1 contributions are very important to enable a Smart City, with its standards already covering the Data and App & support layers as well as contributing to the sensing layer. Communications and networking are dominated by the ITU, with contribution from JTC 1/SC6 while security is heavily contributed to by JTC 1/SC27.

A more detailed model of standardization needs is required to identify all the potential requirements. This is provided by Figure A.15, a three dimensional model.

As we saw with other three dimensional models, each layer can then be extracted to make a two dimensional grid where existing standards can be positioned, gaps identified to eventually define future project. This is illustrated in Figure A.16.

The difference between this model and the smart grid inspired model of Figure A.11 is, principally, that one of the dimensions is life cycle based. Both models can be used to map standards, but they will do it differently. The smart grid inspired model is more ‘domain’ focused (2 out of 3 dimensions) while the Shandong Institute of Standardization model is more IT in nature (2 out of 3 dimensions).

A.3 Conclusions

It is very clear from all these models that the ‘smart’ in a Smart City is ICT based and also that JTC 1 standards play a key role in the implementation of a Smart City. It is also clear

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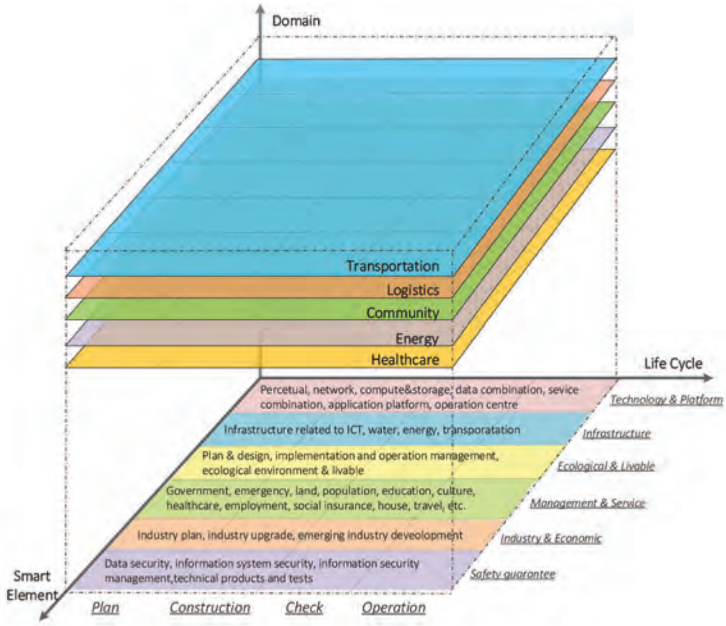

Figure A.15

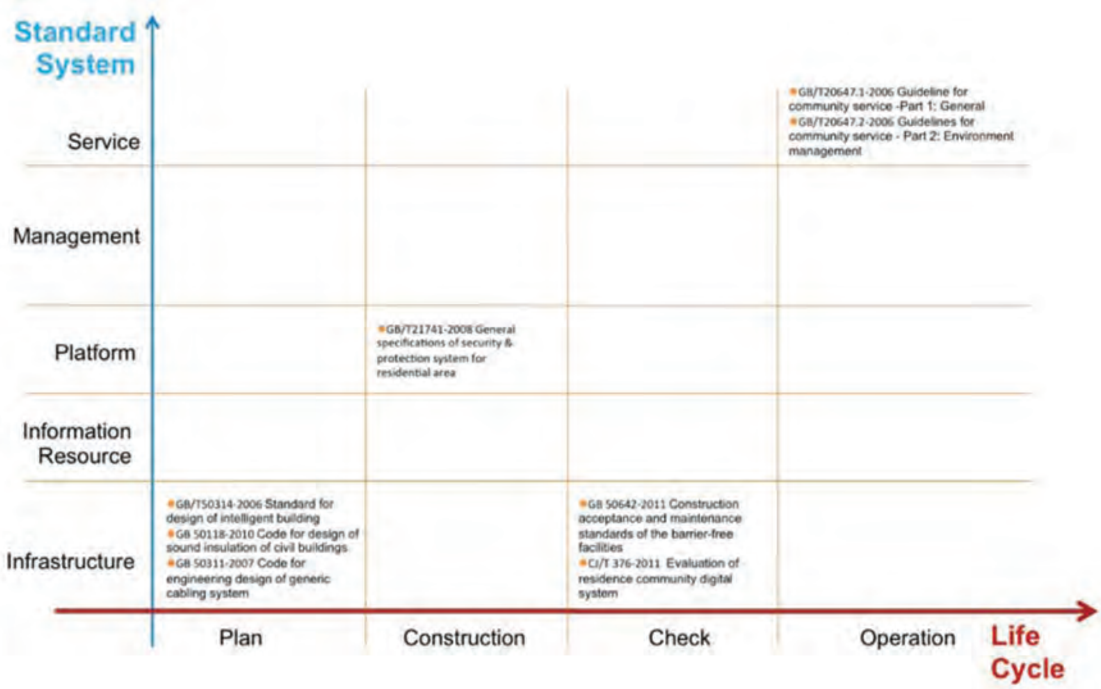

Figure A.16

that building and operating a Smart City is like building and operating an IT enabled organisation.

Through the models presented here, we have explicitly identified standards from WG5, SC6, SC7, SC27, SC32, SC38 and SC40. This list is not exhaustive.

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It is also very visible that close cooperation with ISO TCs would be required given that the domain expertise lies there.

Since it is difficult to communicate effectively without a common vocabulary, and even more difficult to develop IT system in such a situation, it is very apparent that a priority should be put on Smart City vocabulary/ terminology and ontologies.

Figure A.17

To truly develop a market for the IT applications that will make a city 'smart', the ideal approach would be to develop a Reference Business Architecture. This was successfully done by a telecommunication fora, the TM Forum (http://www.tmforum.org/BusinessProcessFramework/1647/home.html). It is interesting to note (see Figure A.17) how the TM Forum promote this Reference Business Architecture on its site.

The Business Process Framework, the e-TOM, was subsequently adopted by the ITU and is freely available at http://www.itu.int/rec/T-REC-M.3050/en.

Given the pubic nature of city administration through the world, it would be natural that a de jure standards organisation like ISO/IEC JCT 1 play a leadership role in the development is a framework of this nature. A starting point for such a development would be conceptual model illustrated in Figure A.2 and described in more details in Annex D.

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Annex B

What is a city?

B.1 General

It is quite clear that, while every city is unique, cities, in general, work in similar ways and there is therefore a great deal that cities can learn from each other and many solutions to city problems that could be widely used.

	City History and characteristics What is the city story, its "brand" and values? Is it a stand-alone city, a hub city or satellite city? What is the size of population? Is it growing, stable or shrinking? What is its demographic mix?	
Environmental context How flat or hilly On what kind of rock it is built If it is by the sea or inland Climate	**City actors** Local authority, Health trusts, electricity and gas suppliers, police, bus and tram companies, voluntary groups, businesses, banks, investors, education providers, social care providers, and, most important of all, the citizen. **Activities** Planning, managing, purchasing, regulating, building and repairing, providing services, generating profit, gaining finance ... **Community facilities and buildings** Homes, hospitals, schools, electricity substations, sports facilities, cinemas, water treatment plants, district heating plants, factories, offices, shops ... **Infrastructures** Gas, electricity, water, sewerage, telecoms, roads and rail, district heating systems ... **Soft Infrastructures** Business / Science / Community / Innovation networks and collaboration structures **Technical systems** Traffic light management, ticketing, billing and payment, automatic number plate recognition ... **City functions or service areas** Employment, Housing, Education, Health, Security, Mobility, Energy, Water, Waste Management, Food Supply chain, Consumer Goods Supply Chain .. **Scale** Citizen, building, block, neighbourhood, district, city, metropolis ...	**Societal context** Laws & regulations Division of power between national and city governments Division of power between agencies within the city Cultural norms Economic structures and situation Political context
	City Governance The task of City Governance is to ensure that all of the functions of the city are delivered effectively at all levels of scale, and are properly co-ordinated to best deliver on the city purposes. **City Purposes** The key challenges facing the city that need to be tackled and the opportunities that need to be grasped. Social, Economic, Environmental ...	

Figure B.1 — A city model

Let's look at a way of mapping out how a city works and see what elements are common to all cities and what are specific to an individual city.

B.2 The city story

Every city is unique. It has its own unique history that explains how it has arrived to where it is today. Every city also has its own "brand" in other words a set of images and

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ideas that are evoked when people think about it. Effectively, the city story describes where the city is now.

Clearly there are other characteristics of a city that will affect the relevance of particular city solutions. For instance, is it a metropolis, or a medium or small city? Is its population growing, stable or shrinking? Is it a stand-alone city, a satellite city of a larger city or a large city working with a number of smaller satellite towns and cities?

B.3 How the city works

The centre box aims to describe the key players and infrastructures in the city and their relationships with each other.

The role of **City Governance** is to ensure that all of the functions of the city are delivered effectively and are properly co-ordinated to best deliver on the city purposes. City Governance is not purely the role of the City council, although it will be the key facilitator of this.

As we have seen, each of the city **functions** will be delivered by a range of different city **actors** undertaking a range of different **activities** and using a variety of different **community facilities** and **infrastructures** at different **scales**. In many cases the citizen themselves will play a key role in the delivery of the city functions. All of the city agencies that work together to deliver a city function, along with all of the community facilities and infrastructures at each of the different levels of scale, form a **city system**.

The centre box, therefore, identifies the aspects of the city that can potentially be supported by the development of Smart City standards.

B.4 The city context

The ability of the city to decide its own future is constrained by two things outside its own control – its environmental context and its societal context.

The **environmental context** includes its climate, how level or hilly it is, whether it is by the sea or is inland and so on. Certain city solutions that work for a city in a cold climate would not work for one in the tropics. Cities on the coast might be vulnerable to tsunamis or sea level rise. Cities which are largely flat might be more suitable for city cycle schemes than those which are largely hilly. Cities built on islands or peninsulas or in valleys may be comparatively constrained in terms of how they can grow in size. It is because of its geography i.e. it’s exceptionally deep and hard rock foundation, that Manhattan has many high rise buildings.

The **societal context** takes into account that any city is part of a larger nation, and its ability to direct its own future will be constrained by the legal and regulatory systems set in place by the national government and by the extent of the powers that have been devolved to it. It also takes into account cultural issues, such as the attitude of the general population to issues such as cycling and green issues, the relative roles of men and women in society and so on.

A city needs to review potential common city solutions and standards to see how well they fit in with its environmental and societal context.

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B.5 The city purposes

The city purposes are the key aims set by the city to tackle the major challenges and to benefit from the major opportunities that the city faces. They will be based to a certain extent on the city's story and its own strengths and weaknesses. The city purposes will probably be adopted as such by the city council but will be developed through widespread participation of all key stakeholders, specifically the citizen. All the city purposes will be focused on the key needs of the residents, businesses and visitors to the city.

For instance city purposes might be to reduce the carbon footprint of the city, to bring more of a particular kind of employment into the city, to improve the health of the citizens etc.

The process of identifying these will often involve a wide range of stakeholders. Once they have been agreed, the city leadership will develop a strategy to address these challenges and opportunities, and this strategy will involve bringing together city systems to work together seamlessly in a specific way. The precise way that this needs to be done will depend on the specific purposes adopted by the city.

For instance, if the city purpose is to improve the health of the citizen, that will, of course involve the health system. However it may also involve supporting the citizen in getting involved in more healthy leisure activities, in encouraging more journeys to be taken by bicycle, in improving the air quality by tackling pollution etc.

In other words, while it is important that each of the individual city systems work effectively, city governance is about ensuring that these systems can work together in an effective way to deliver the key city purposes.

B.6 What is common and what is unique

The items and the relationships in the central box are common to all cities and are the basis for the development of common approaches and standards.

The environmental and societal contexts help define which solutions, from among the common city solutions and standards, are practical for any individual city.

The city purposes will determine the priority actions for any individual city – i.e. which common city solutions the city would want to implement first.

The City History and Characteristics define what is unique about any city. The city leadership would choose those common city solutions that are consistent with its history, values and characteristics.

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Annex C

The capital I-model

C.1 General

The capital letter “I” of I-model is to distinguish it from the small letter “i” which expresses information system symbols, such as i-mode and iPhone. The capital letter “I” is taken from the initial of “Infrastructure” which means a society’s infrastructure. This is why this is called a “capital I model.”

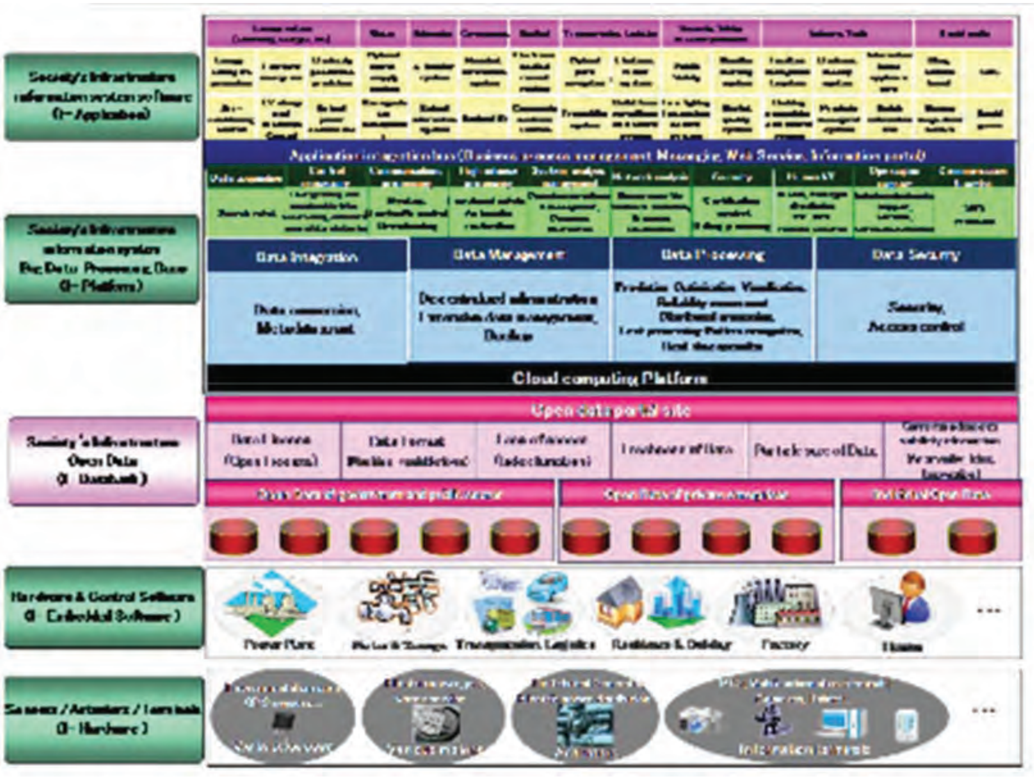

Figure C.1

Source: Japan Electronics and Information Technology Industries Association, 2013. http://home.jeita.or.jp/cgi-bin/page/detail.cgi?n=581&ca=1 (Japanese only)

Five classes (layers) are defined in the “capital I-model”.

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C.2 I- Application (Infrastructure - Application)

I- Application layer shows the various applications in an open society's infrastructure system. The data processed in the layer of I- Platform is utilized, and relief and safe and comfortable service are provided to a society's infrastructure.

C.3 I- Platform (Infrastructure - Platform)

I- Platform layer is a technical basis for offering the relief and the safe and comfortable function which are needed in the practical use stage of a society's infrastructure. I- Platform layer is regarded as a common base ground layer for each field-oriented individual application (I- Application) to work. In particular, importance is attached to four functions important for data analysis. It is the function, prediction, and optimization, visualization and a real-time operation function, the data security function, etc. to manage the data which specifically unifies the data of the various forms acquired from two or more infrastructures and which was functioned and collected. Since cooperation of various service compartments and mutual use of data are assumed, while data exchange is standardized, open nature and the mutual availability of information need to be secured.

C.4 I- Databank (Infrastructure - Databank)

I- Databank layer shows the state of the data public presentation acquired in an I-embedded software layer, and maintenance. I- Databank layer is the mechanism of in addition to the data which the government and the public institution represented by open data etc. hold performing accumulation, secondary elaboration, etc. across the board also including the data about private enterprises or an individual so that correspondence flexible at the time of a disaster, etc. can be performed.

Moreover, the stored data requires the correspondence to subtlety information, including improvement in grant of a suitable data license, the data format which is easy to use, and the access nature to data, reservation of the sufficient freshness of data and particle size, personal information, etc.

C.5 I- Embedded Software (Infrastructure - Embedded)

I- Embedded Software layer consists of hardware and control software.

Although the conventional closed society's infrastructure system is built even on this class, it is required to propose the open society's infrastructure model included to the practical use stage from now on, and it is considering it as I- Embedded software, without calling it a system.

In the I- Embedded Software layer, the role which supplies the information acquired from apparatus and subsystems, such as a sensor and an actuator, to a higher layer in real time is played.

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C.6 I- Hardware (Infrastructure - Hardware)

I- Hardware layer shows apparatus and the subsystem which are the components of various society's infrastructures, such as a power generation system and an advanced traffic system.

The component of this layer consists of hardware and its embedded software, such as a sensor, an actuator, and an information terminal.

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Annex D

Domain Knowledge Model for Smart City: the Core Conceptual Model

D.1 Background

As the emergence of the requirement of building Smart Cities across many countries, the Domain Knowledge Model of Smart City becomes necessary for two reasons. First, the aggregation of multi-source and heterogeneous data and service needs a set of unified concepts and terminologies. Second, the development of applications needs the support of common knowledge of Smart Cities.

The Domain Knowledge Model of Smart City has abundant contents and involves many domains and cities. In order to support cross-domain and cross-city interoperation of knowledge, we should concise the common concepts and their relationship from domains and cities and construct a core concept model. Furthermore, the domain knowledge in Smart City is abundant and complex. No single individual or organization can build it comprehensively and thoroughly. The model should use swarm intelligence to build it and the participants should work collaboratively. To support better cooperation, we should construct a standard and core concept model that can specify terms from different stakeholders, support semantic understanding and give standard knowledge expression.

D.2 Purpose/Goal

This model aims to:

a) Support interoperation of cross-domain knowledge model:

The model provides a sharing model of common knowledge in Smart City's domains and supports interoperation among cross-domain knowledge model.

b) Support extension and customization for specific domains and cities:

The model only defines the cross-domain and cross-city core concepts and their relationships. It supports extension and customization for specific domains and cities to reflect their differences.

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D.3 Scope

This model will apply to following circumstances:

— Support cities to build their own Smart City Knowledge Model which processes specific city features.

— Support Smart City related domains to build their own Smart City Knowledge Model which has specific domain characteristics.

D.4 References

This model refers to the following standards, specifications, articles and papers:

[1] PAS 180:2014, Smart Cities – Vocabulary, BIS.

[2] SSC-0100-rev-2, Smart Sustainable Cities – Analysis of Definitions, ITU-T FG SSC.

[3] PAS 181:2014, Smart City framework – Guide to establishing strategies for Smart Cities and communities, BSI.

[5] SSC-0110, Technical Report on Standardization Activities and Gaps for SSC and suggestions to SG5, ITU-T FG SSC.

D.5 Terms

TBD

D.6 Overview

The model incorporates a high-level core ontology covering core concepts (e.g., social organizations, physical entities and information entities etc.) involved in urban life and relations among them. The model defines the common and core concepts in Smart Cities, it specifies:

1. The common sharing concepts in Smart Cities' various domains.

It only gives the definition of cross-domain core concepts not the concept in specific domain.

2. The common sharing concepts in cities.

It only defines cross-city and cross-area core concepts not individual concepts in specific city.

Smart City Core Conceptual Model classifies the related concepts into seven categories (as shown in Figure 1); the details are described as below:

- ***EntityPrimitive:*** specifies the recognizable basic objects in Smart City; consists of physical objects, cyber objects and social objects.

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- ***RolePrimitive:*** specifies a set of rights and responsibilities undertaken by entities in Smart City when they cooperate or interact.
- ***ServicesPrimitive:*** specifies a set of functions provided by entities or roles taken by entities, which is consumed by other entities or roles taken by entities.
- ***EventPrimitive:*** specifies interactions or incidents occurred in specific place and time.

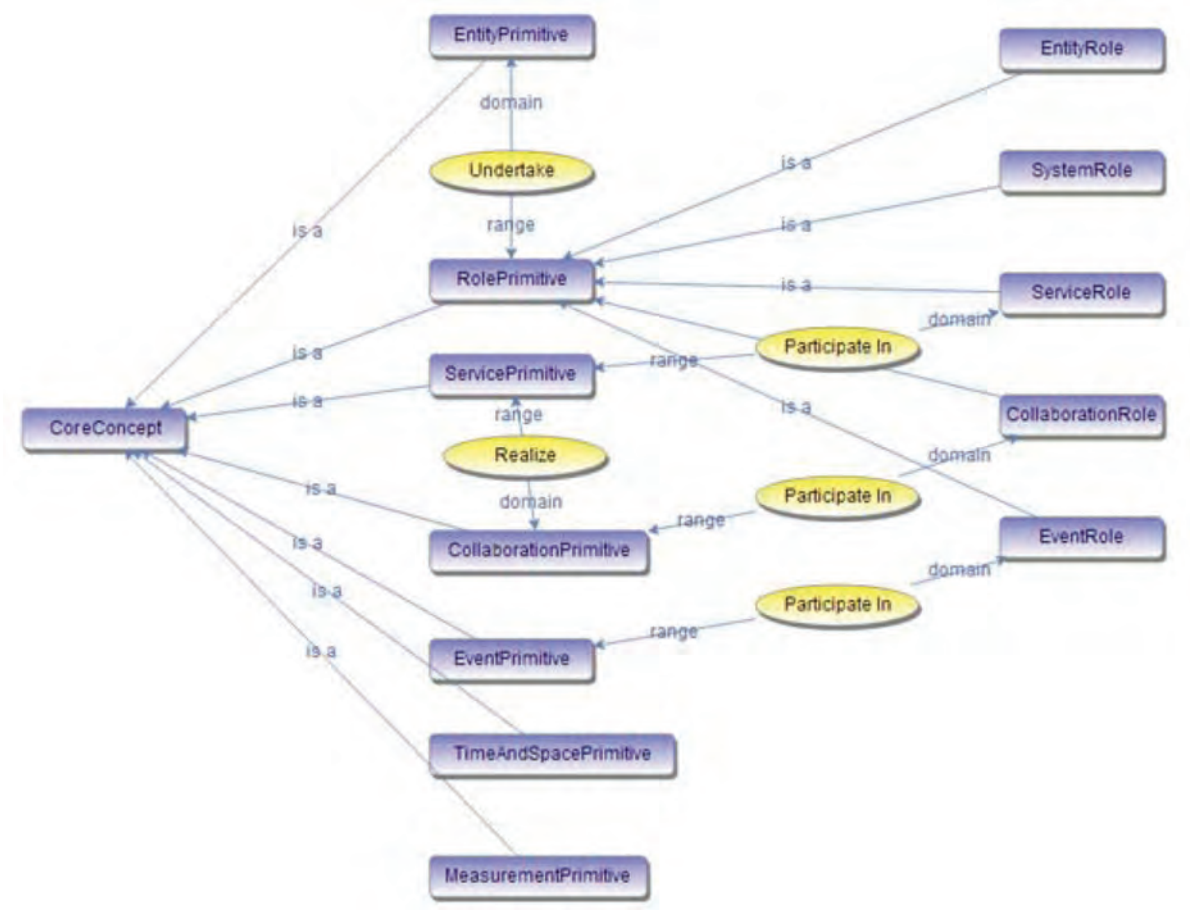

Figure D.1 — Core Conceptual Model Top-level Design

- ***CollaborationPrimitive:*** specifies the processes and messages related to entities' interactions.
- ***TimeAndSpacePrimitive:*** specifies the concepts related to time and space in Smart City.
- ***MeasurementPrimitive:*** specifies the measurements and units for quantifying or assessing the entities' attributes in Smart Cities.

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The relationships between primitives of Core Conceptual Model are described as below:

- ***Is a:*** a concept is a special case of another concept, e.g.: an instance of “EventRole” is also an instance of “RolePrimitive” too.
- ***Realize:*** services come from the collaborations between entities, and the instances of “CollaborationPrimitive” enable the instances of “ServicePrimitive”, so they have “Realize” relationship.
- ***Undertake:*** an entity can “undertake” a role, e.g.: an instance of “EntityPrimitive” undertake an instance of “RolePrimitive”.
- ***Participate in:*** entities with different roles participate in various events in Smart City, e.g. an instance of “EntityPrimitive” participates in an instance of “EventPrimitive” with undertaking an instance of “RolePrimitive”.

D.7 Concepts

D.7.1 EntityPrimitive

D.7.1.1 Introduction

The concepts in this part are used for describing the recognizable basic objects in Smart City, which describes entities in Smart City from the perspective of physical space, cyber space and social space.

D.7.1.2 PhysicalEntity

Describe the entities in physical space, divided into three categories:

1. Asset: a set of assets belong to Smart City, defined by specific domain or specific city.
2. City-Infrastructure: the substructure of city, including building infrastructure, ICT infrastructure, water infrastructure, energy infrastructure, transportation infrastructure and environmental-protection infrastructure.
3. Resource: various resources in Smart City, including energy, water and land.

D.7.1.3 CyberEntity

Describe the cyber entities of cyber space in Smart City, divided into two categories:

1. Data: information for statistics or count in the city.
2. Information-System: systems used for processing information flow and different goals

D.7.1.4 SocalEntity

Describe the social entities of Smart City, divided into two categories:

1. Person: concept related to individuals in Smart City.

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2. Organization: a set of organizations or agencies assembled by specific goals, including government branch, institution, enterprise and social organization.

D.7.2 RolePrimitive

D.7.2.1 Introduction

According to different targets, the concepts in this part describe the set of rights and responsibilities undertaken by entities in Smart City when they cooperate or interact with each other, provide unified glossary system for entities' relationship in Smart City, involve five different aspects including event, entity, system, collaboration and service.

D.7.2.2 EventRole

Describe the roles related to the events in Smart City, e.g. "Event Initiator".

D.7.2.3 EntityRole

Describe the roles related to entities in Smart City.

D.7.2.4 SystemRole

Describe the roles that a system can undertake, divided into SenseRole and ActuateRole.

1. SenseRole: can sense the external variation and have an effect on system.

2. ActuateRole: can obtain instructions from system and have an effect outside.

D.7.2.5 CollaborationRole

Describe the roles related to collaboration.

D.7.2.6 ServiceRole

Describe the roles related to services.

D.7.3 ServicePrimitive

D.7.3.1 Introduction

Concepts in this section illustrate services or functions which are provided for citizens in Smart City. It is composed by 21 categories including E-government, MarketSurveillance, PublicSafety, EmergencyManagement, LandManagement, PopulationManagement, CommunityManagement, TransportationServices, HousingPropertyManagement, EnergyManagementServices, LogisticsServices, EducationServices, CulturalServices, HealthServices, EmploymentServices, SocialSecurityServices, PensionServices, HousingSecurityServices, TourismServices, FinancialServices and E-commerce.

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D.7.3.2 E-government

Describe Smart City government utilises electronic means to implement the city administration.

D.7.3.3 MarketSurveillance

Describe relevant services in Smart City which aims to maintain normal economic order in market. Related Content services include supervision of commodities, operators, market prices, measurement, trademarks, and market ticket.

D.7.3.4 PublicSafety

Describe public safety-related services in Smart City, such as information security, social security, food security, public health security, public transportation safety.

D.7.3.5 EmergencyManagement

Describe relevant emergency management services in Smart City which in response to a major accident hazards, including a series of necessary measures to protect public life and property safety.

D.7.3.6 LandManagement

Describe related services of urban land management in Smart City which provide services that organize, coordinate and supervise the development and utilization of land resources.

D.7.3.7 PopulationManagement

Describe relevant population management services in Smart City, including management of resident population, demographic changes, migrant population, as well as the quantity and quality of urban population.

D.7.3.8 CommunityManagement

Describe the services which focus on maintaining the normal order and promoting development of the community in Smart City.

D.7.3.9 TransportationServices

Describe transportation-related services in Smart City, such as public transport, private transport services, and traffic information services.

D.7.3.10 HousingPropertyManagement

Describe the wisdom services related to housing property in Smart City. For example, real estate transfer, etc.

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D.7.3.11 EnergyManagementServices

Describe Smart City management service related to the process of energy production and consumption.

D.7.3.12 LogisticsServices

Describe urban logistics services in Smart City.

D.7.3.13 EducationServices

Describe education-related services in Smart City. For example online learning services, pre-school education, compulsory education services, and higher education services.

D.7.3.14 CulturalServices

Describe culture-related services in Smart City. For instance, Museum Service, library services, etc.

D.7.3.15 HealthServices

Describe medical and public health services in Smart City.

D.7.3.16 EmploymentServices

Describe service about public employment in Smart City which help citizens' labour remuneration or business income and could create material wealth or providing labor force for the community.

D.7.3.17 SocialSecurityServices

Describe welfare serviced provided by the government and its social security organizations.

D.7.3.18 PensionServices

Describe pension-related services for the elderly in Smart City which provide the necessary living services to meet their basic needs of their material life and spiritual life.

D.7.3.19 HousingSecurityServices

Describe housing support services for the housing difficulties groups in Smart City. Such as applying for "affordable housing", "welfare housing" and so on.

D.7.3.20 TourismServices

Description of tourism-related services in Smart City.

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D.7.3.21 FinancialServices

Describe finance-related services in Smart City. For example business start-up services.

D.7.3.22 E-commerce

Describe electronic trading activities and related trading services in Smart City.

D.8 EventPrimitive

The concepts in this part are used for describing interactions or incidents occurred in specific place and time, provide unified forms for event expression in Smart City, have basic properties including time, location, result-status, participant and so on.

D.8.1 CollaborationPrimitive

D.8.1.1 Introduction

The concepts in this part model all kinds of event or operation flows in Smart City. These concepts provide a unified format for the event expressions and message transmissions, modelling the coordination processes, restrictions and messages transmitted during them. Thus this set of concepts provide support for the interactions among entities in Smart City, basically consists of two aspects, Message and Protocol.

D.8.1.2 Message

The class Message defines the unified format for messages passed in Smart City, including message provider, message type, emergency, etc.

D.8.1.3 Protocol

The class Protocol defines the processes and restrictions followed during the communication and collaboration among social entities in Smart City.

a) Process: defines the sub-processes and steps during the collaborations.

b) Restriction: defines the restrictive factors of entities during collaborations.

D.8.2 TimeAndSpacePrimitive

D.8.2.1 Introduction

The concepts in this part contain time and location related concepts used in Smart City.

D.8.2.2 Time

Defines concepts related to time that are used in Smart City, e.g. time, time intervals, date, etc.

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D.8.2.3 Location

Defines concepts related to geographical location in Smart City, e.g. latitude and longitude, regional landmark, etc.

D.8.3 MeasurementPrimitive

D.8.3.1 Introduction

The concepts in this part are used to formulize the measurement of all kinds of entity properties, including unified measurable indicators and units. Moreover, these concepts are also used for modelling KPI of each department in Smart City, providing reference for related issues.

D.8.3.2 KPI

The class KPI models measurable indicators at each levels and departments in Smart City, e.g. Temperature, population, tax, detection rate, etc.

D.8.3.3 Measurement

The class Measurement provides definition of measurable indicators according to various official standards, e.g. length, area, heat, voltage, etc.

D.9 Relationships

D.9.1 Is a

A concept is a special case of another, representing concept in Smart City evolve from general cases into special ones. “EventRole” has “is a” relationship with “RolePrimitive”; as a result, the instances of “EventRole” are also instance of “RolePrimitive”.

D.9.2 Realize

A concept can come true owing to another concept, representing some objects’ existence in Smart City strong rely on some other objects. For example, entities’ collaborations produce services, in other words, service is realized by collaboration.

D.9.3 Undertake

An entity can have different responsibilities and rights when they join in collaboration and interaction. For example, person has the rights for initiating event and responsibilities for dealing with it, in other words, “Person” undertakes “EventRole”.

D.9.4 Participate in

Events in Smart City need various entities’ with different roles to be a part of their own. For example, “Person” participate in “Event” with undertaking “EventRole”.

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D.9.5 9 Extension principles

Following rules should be followed when constructing domain/city featured "domain knowledge models of Smart City" basing on the Core Conceptual Model.

D.9.6 Scientificity

Scientificity is the basis of designing the Core Conceptual Model. This demands that the design should be based on the basic principles of Smart City and informatization. The concepts picked should express the idea and main content of Smart City, and reflect the rules and characteristics of the development of Smart City objectively and accurately.

D.9.7 Operability

Smart City involves a wide range of concepts and a complicated set of knowledge. Even limited to a specific sub-domain, related concepts, relations and rules is still a great number. Therefore, the construction and standardization of knowledge model is not an easy job. Thus out of the concern of goal driven principle, a limited range of concepts should be covered in the model. We believe that only knowledge that serves the goals "interconnection of data and system" and "the development and evolution of system" should be brought into the domain knowledge models, otherwise should not.

D.9.8 Comprehensiveness

Domain knowledge models of Smart City are the basis of the construction related systems in Smart City. No important aspects of domain or city should be ignored. The domain knowledge models should comprehensively, systematically and constitutionally reflect and cover all aspects of knowledge that serve the goals of "interconnection of data and system" and "the development and evolution of system".

D.9.9 Extensibility

As the number of concepts in Smart City is growing constantly, the domain knowledge model needs to be evolved and the concepts modelled should be improved constantly as well. Therefore, the domain knowledge models should achieve good extensibility.

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Annex E

Existing indicators for Smart Cities

This section provides a selection of the indicators used in the three sets reviewed in ISO/TR 37150:2014, and in the technical report on Smart and Sustainable City KPIs being developed by the ITU-T Smart and Sustainable Cities Focus Group. The aim is to give a flavour of the sort of indicators being used or developed at the moment.

E.1 Indicators from the ISO/TR 37150 survey

E.1.1 Global City indicators

Indicator		**Supporting indicator**
Education	Student/teacher ratio	Percentage of school-aged population enrolled in schools
	Percentage of students completing primary and secondary education: survival rate	Percentage of male school-aged population enrolled in schools
	Percentage of students completing primary education	Percentage of female school-aged population enrolled in schools
	Percentage of students completing secondary education	
Fire and Emergency Response	Number of firefighters per 100,000 population	Response time for fire department from initial call
	Number of fire related deaths per 100,000 population	
Health	Number of in-patient hospital beds per 100,000 population	Number of nursing and midwifery personnel per 100,000 population
	Number of physicians per 100,000 population	
	Average life expectancy	
	Under age five mortality per 1,000 live births	
Recreation		Square metres of public indoor recreation space per capita
		Square metres of public outdoor recreation space per capita
Safety	Number of police officers per 100,000 population	Violent crime rate per 100,000 population
	Number of homicides per 100,000 population	

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Indicator		Supporting indicator
Solid waste	Percentage of city population with regular solid waste collection	Percentage of the city's solid waste that is disposed of in an incinerator
	Percentage of city's solid waste that is recycled	Percentage of the city's solid waste that is burned openly
		Percentage of the city's solid waste that is disposed of in an open dump
		Percentage of the city's solid waste that is disposed of in a sanitary landfill
		Percentage of the city's solid waste that is disposed of by other means
Transportation	Km of high capacity public transit system per 100,000 population	Number of two-wheel motorized vehicles per capita
	Km of light passenger transit system per 100,000 population	Commercial Air Connectivity (number of non-stop commercial air destinations)
	Number of personal automobiles per capita	Transportation fatalities per 100,000 population
		Annual number of public transit trips per capita
Wastewater	Percentage of city population served by	Percentage of the city's wastewater receiving primary treatment
	Percentage of the city's wastewater that has received no treatment	Percentage of the city's wastewater receiving secondary treatment
		Percentage of the city's wastewater receiving tertiary treatment
Water	Percentage of city population with potable water supply service	Total water consumption per capita (litres/day)
	Domestic water consumption per capita (litres/day)	Percentage of water loss
	Percentage of city population with sustainable access to an improved water source	Average annual hours of water service interruption per household
Energy	Percentage of city population with authorized electrical service	Total electrical use per capita (kWh/year)
	Total residential electrical use per capita (kWh/year)	The average number of electrical interruptions per customer per year
		Average length of electrical interruptions (in hours)

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Indicator		Supporting indicator
Finance	Debt service ratio (debt service expenditure as a percent of a municipality's own-source revenue)	Tax collected as percentage of tax billed
		Own-source revenue as a percentage of total revenues
		Capital spending as a percentage of total expenditures
Governance		Percentage of women employed in the city government workforce
Urban Planning	Jobs/Housing ratio	Areal size of informal settlements as a percent of city area
		Green area (hectares) per 100,000 population
Civic Engagement	Voter participation in last municipal election (as a percent of eligible voters)	Citizen's representation: number of local officials elected to office per 100,000 population
Culture		Percentage of jobs in the cultural sector
Economy		Percentage of persons in full time employment
Environment	PM10 concentration	Greenhouse gas emissions measured in tonnes per capita
Shelter	Percentage of city population living in slums	Percentage of households that exist without registered legal titles
		Number of homeless people per 100,000 population
Social Equity		Percentage of city population living in poverty
Technology & Innovation	Number of internet connections per 100,000 population	Number of new patents per 100,000 per year
		Number of higher education degrees per 100,000
		Number of telephone connections (landlines and cell phones) per 100,000 population
		Number of landline phone connections per 100,000 population
		Number of cell phone connections per 100,000 population

E.1.2 The Green City Index series

Indicator		Explanation
CO_2	CO_2 intensity	
	CO_2 emissions	
	CO_2 reduction strategy	

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Indicator		Explanation
Energy	Energy consumption	
	Energy intensity	
	Renewable energy consumption	
	Clean and efficient energy policies	
Buildings	Energy consumption of residential buildings	
	Energy-efficient buildings standards	
	Energy-efficient buildings initiatives	
Transport	Use of non-car transport	
	Size of non-car transport network	
	Green transport promotion	
	Congestion reduction policies	
Waste & Land use	Municipal waste production	
	Waste recycling	
	Waste reduction policies	
	Green land use policies	
Water	Water consumption	
	System leakages	
	Wastewater system treatment	
	Water efficiency and treatment policies	
Air quality	Nitrogen dioxide	
	Sulphur dioxide	
	Ozone	
	Particulate matter	
	Clean air policies	
Environmental Governance	Green action plan	
	Green management	
	Public participation in green policy	

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E.1.3 Smart City realized by ICT (Proposed by Fujitsu)

Indicator		**Explanation**
Service	annual gross products of a community, per-capita (USD)	
	number of in-patient hospital beds per 100,000 population	
	fuel efficiency of vehicles	
Environmental impact	environmental impact of the city	
Energy	power outage frequency rate in a community (%)	
	annual greenhouse gas (GHG) emissions of a community (CO2 equivalent ton)	
	ratio of renewable energy in the total energy	
Biodiversity	ratio of biodiversity conservation	
Water	water-leakage rate in a community (%)	

E.2 Key performance indicators from ITU-T FG SSC

Indicator		**Explanation**
Network Facilities	Share of network infrastructures in total investment	Ratio of investments on urban network infrastructure to overall fixed assets investments.
	Public ICT spending per capita	Personally public expenditure per average income on ICT (including networks, software, hardware and services).
	Percentage of household broadband access	Proportion of broadband access covering all family in the city (including all kinds of access manners).
	Household network bandwidth on average	Average network bandwidth used per urban family (including all kinds of access manners).
	Percentage of territory covered by mobile broadband access	Proportion of mobile broadband access throughout the city (including all kinds of access manners).
	Average of available mobile broadband bandwidth	Average bandwidth of urban mobile network.
	Coverage rates of next generation broadcasting network	Proportion of next generation broadcasting network covering all family in the city.
	Share of network infrastructures in total investment	Ratio of investments on urban network infrastructure to overall fixed assets investments.
	Time to recover from telecommunication congestion	Average time used for recovering from telecommunication congestion per resident.
	Percentage of territory with EMF monitoring	Proportion of urban space covered with EMF observing devices.

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Indicator		Explanation
Information Facilities	Percentage of enterprises providing network based services (e-commerce, e-learning, e-entertainment, cloud computing)	Proportion of enterprises which provide network based services to urban citizens (including e-commerce, e-learning, e-entertainment, cloud computing and so on).
	Appliance of cloud computing services	Proportion of business serving for enterprises, government and other organizations that use cloud computing resources, both hardware and software.
	Appliance of GIS	Proportion of business serving for enterprises, government and other organizations that uses Geographic Information System
	Service duration (reliability)	Average reliability service time network based services can provide (including e-commerce, e-learning, e-entertainment, cloud computing and so on).
Environment	Proportion of information publish on environmental quality	Scale of information published in automatic and intelligent environment inspection by means of advanced ICT technologies.
	Proportion of water resource under protection through advanced ICT measures	Scale of automatic and intelligent water resource inspection by means of ICT.
	Effect of flood control monitoring by means of ICT measures	Proportion of success in the early warning and emergency detection during flood period with the help of ICT.
	Proportion of water pollutant control by means of ICT measures	Scale of automatic inspected pollutant sources that would affect water environment.
	Proportion of air pollution monitoring by means of ICT measures	Scale of automatic inspected pollutant sources that would affect atmospheric environment.
	Proportion of toxic substances monitoring by means of ICT measures	Scale of automatic inspected pollutant sources that emit poisonous substance.
	Proportion of significant pollution source monitoring	Mean the informative monitoring proportion of the key pollution sources in the city. The proportion of significant pollution source monitoring of the Smart City should reach 100%.
	Proportion of noise monitoring by means of ICT measures	Scale of automatic inspected noisy sources with the help of ICT
Building	Application level of energy saving technologies	Degree of energy efficient technologies applied in all the services and industries, including solar power, electric vehicle, energy conservation electric appliances, etc.
	Percentage of intelligent buildings	Scale of intelligent buildings of all the constructions in a city or area.
	Proportion of homes using smart home monitoring system	Scale of families that utilize advanced technologies to enhance home experience.
	Improvement of indoor energy efficiency with ICT measures	Effect of energy saving as a result of utilizing advanced ICT technologies.

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Indicator		Explanation
Energy and natural resources	Improvement of electricity civilian usage (per capita) with ICT measures	Contribution per capita by the efficient use of electricity.
	Improvement of electricity industrial usage (per GDP) with ICT measures	Contribution per GDP by the efficient use of electricity.
	Improvement of water civilian usage (per capita) with ICT measures	Contribution per capita by the efficient use of water.
	Improvement of water industrial usage (per GDP) with ICT measures	Contribution per GDP by the efficient use of water.
	Sustainability of electricity supply	Level of electricity supplied steadily and continuously.
	Improvement of fossil fuel usage with ICT measures (per GDP)	The efficiency raise of traditional fuel usage through the help of ICT
	Improvement of rare metal/noble metal usage (per GDP) with ICT measures	Contribution per GDP by the efficient use of rare metal/noble metal.
Innovation	Percentage of R&D expenditure in GDP	Ratio of investment of research and development to the city's GDP, including academic research input.
	Share of knowledge-intensive enterprises	Proportion of high-tech enterprises with high value-added products and world-wide competence in all the registered enterprises.
	Patent applications per inhabitant	Average number of new patents shared by each citizen.
	Importance as decision-making center (HQ etc.)	Percentage of enterprises which locate its significant research centers or headquarters.
	SSC new projects opportunities.	Number of programs, initiatives, awards with opportunities to create new projects working in SSC. Government, grant makers, multilateral organizations, private sector, may sponsor them.
Knowledge Economy	Percentage of smart industries in total investment	Proportion of investment into the smart industries, including emerging high tech and upgrading traditional areas.
	Growth rate of import-export related to smart industry	Annual rate of increase in import and export.
	Percentage of smart industries in GDP	Economic scale contributed to GDP by smart industries.
	Employment rate in knowledge-intensive sectors	Ratio of employees in knowledge-intensive areas to the overall employment number, the more advanced SSC the higher employment rate in knowledge-intensive sectors.
	Percentage of e-commerce transaction amount	Proportion of the e-business transactions accounted in all transactions, a proxy indicator of the industry promotion.

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Indicator		Explanation
Governance	Digital access to urban planning and budget document	Proportion of urban planning and operation information documented in digital form, which is better for share and storage.
	Coverage of food and drug trace-back monitoring	Mean the coverage rate of the food and drugs which can realize from the production to sales by using the food and drug traceability system in the total main kinds of food and drugs.
	Penetration rate of community administration service	Mean the information monitoring proportion of the community administration service.
	Penetration rate of government on-line service	The proportion of the entire online administrative examination and approval matters accounted in the total matters.
	Percentage of government information open	Refer to the percentage of the unclassified documents from the government to flow and deal with through the network. If the information accomplish with open data, it is available to citizen, journalist, developer communities, etc.
Transportation	Coverage of installation of road sensing terminals	Proportion of roads with all kinds of sensors for traffic monitoring.
	Coverage of parking guidance systems	Proportion of parking areas with parking guidance systems.
	Coverage of electronic bus bulletin board	Proportion of stations with electronics bus bulletin board for information forecasting.
	Ratio of received traffic information (per capita)	Average traffic information received by the residents via various terminals.
	Clean energy Transport	Percentage of Clean-energy Transport use (electric train, subway/metro, tram, cable railway, electric taxis or cars, electric scooter, bicycling)
	Clean energy sharing transport	Implemented projects of Bike sharing, car sharing.
Security and safety	City video surveillance penetration	Number of video cameras in overall population.
	Crime rate reduced as a result of ICT usage	The lower crime rate, the safer the city.
	Accident ratio(victim, damaged object)	Ratio of all kinds of accidents predicted by ICT measures in a period of time.
	Penetration of ICT for disaster prevention	Number of sensing terminals in disaster-prone areas in overall population.
	Information security events ratio	Ratio of all kinds of information security events in a period of time.
	Publication rate of disaster alert	The publication rate of timely alerts for natural disasters (such as earthquake, storm, typhoon, etc.) suffered in the city within one year.
	Damage expenditures reduced due to ICT usage	Ratio of damage expenditures in overall expenditure.

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Indicator		Explanation
Sanitation	Solid waste disposal management with ICT measures	Waste recycling can reduce risks to human health, avoid environmental hazards, conserver and protect scarce natural resources, provide economic benefits and reduce reliance on raw materials and energy.
	Sewage discharge management with ICT measures	Proportion of sewage under automatic inspection with the help of ICT.
	Improvement of waste water recycling with ICT measures	Raise of water recycling with the help of ICT.
Healthcare	Percentage of archiving electronic health records for residents	Refer to ratio of residents who keep the archive of electronic health records. This value should be 100% in Smart Sustainable Cities.
	Usage rate of electronic medical records	Refer to ratio of hospitals where electronic health records are used. This value should be 100% in Smart Sustainable Cities.
	Sharing rate of resource and information among hospitals	Sharing rate of information especially electronic health records among hospitals.
	Coverage rate of community e-health service	The proportion of the communities with a comprehensive information service system accounted in all communities. The coverage rate of community information service system for the Smart City should be more than 99%.
Education and training	Effectiveness of hatching smart tech from knowledge centers (research centers, universities etc.)	The ability to cultivate ideas into industries by R&D centers and universities. This is how R&D centers and universities directly serve SSC.
	Penetration of e-learning system	The ratio of people using the e-learning system in overall population.
	Employment rate enhanced by smartness	Smart tech help people to better recognize themselves and dig their potentials, shape and reshape their skills, more efficiently fit into jobs
Openness	Immigration-friendly environment contributed by ICT measures	Various applications and services, to help new citizens cross the barrier of strangeness. Immigration is a key solution to global urbanization.
	International communication and cooperation enhanced due to ICT measures	Popularizing level of E-conference, tele-meeting, Facebook and Twitter that help international communication easily. It also helps citizens to know the outside world better.
	Tourism flourishing contributed by ICT measures	Online advertisement, e-tourism, e-shopping and convenient payment can help attract tourists worldwide and better utilize travel resources like historical and cultural etc.

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Indicator		Explanation
Participation in public life	Improvement of turnout at city hearings by means of ICT	The rate of attendance at all kinds of city hearings. The higher this value, the more active residents involve in municipal administration.
	Online civic engagement	Ratio of times residents involving on-line in the urban administration including participation with gov and others, i.e, civic apps
	Participation in voluntary work due to ICT help	Ratio of residents with voluntary experience to overall population. Voluntary work thrived due to smart measures.
Convenience and comfort	Satisfaction level with network based services	Satisfaction level with network based services of the city is assessment from four aspects: multiformity, convenience, stability and practicability
	Satisfaction with environmental safety smartness	Refer to satisfaction with the pollution control and monitoring, environmental event response etc.
	Convenience of government services	The feelings of convenience of public service provided by government department.
	Satisfaction with anti-corruption	The smart Government improves the policies and eliminates corruption; improve the public satisfaction with the government's anti-corruption.
	Convenience of smart traffic information administration and service	The feelings of convenience of obtaining the traffic information, it could be usually measured in the convenience of obtaining the information via smart terminals.
	Satisfaction with quality to public transport	Through the consideration of the factors just like the convenient of the travel, the costs of the travel, travel time-consuming, etc., to show the public's satisfaction with the quality of public transport and the convenience of transference among subway, railway, waterway, airline and road traffic.

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Indicator		Explanation
	Satisfaction with traffic safety	Refer to satisfaction with the protection and measures of public traffic safety.
	Satisfaction with prevention and control of crime and security	Satisfaction with the actions and measures of prevention and control of crime.
	Satisfaction with countermeasures against disaster	Satisfaction with the actions and measures of prevention and control of disaster.
	Satisfaction with food Safety smartness	Satisfaction with food safety especially food trace-back and monitoring measures.
	Convenience of urban medical care	The feelings of convenience of obtaining medical, nursing service.
	Satisfaction with quality of health and welfare system	Refer to feelings and assessment of quality of health service.
	Convenience for citizens to access education resource	Whether it is easy enough for citizens to get the knowledge they need in various forms, digital or traditional, campus or community. Education resources should be well documented and well indexed with highly efficient searching engine help and least invalid resources.
	Penetration of smart impediment removal (accessibility) system	Smart system in favor of the impediment
	Leisure time increased due to smartness	Does smartness helps you increase efficiency and convenience and thus you feel more leisure time
	Perception on proof against risk of poverty	Feelings that innovative tech proof poverty
	Penetration of teleworking system	The ratio of people using the teleworking system in overall population.

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International Organization
for Standardization

ISO Central Secretariat
Ch. de Blandonnet 8
CP 401
CH – 1214 Vernier, Genève
Switzerland

iso.org

International Electrotechnical
Commission

IEC Central Office
3, rue de Varembé
P.O. Box 131
CH – 1211 Genève 20
Switzerland

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