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SYSTEMS REFERENCE DELIVERABLE

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Smart city system ontology – Part 1: Gap analysis

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Part 1: Gap analysis

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The text of this Systems Reference Deliverable is based on the following documents:

Draft	Report on voting
SyCSmartCities/322/DTS	SyCSmartCities/334/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Systems Reference Deliverable is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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INRODUCTION

Ontology is becoming a key subject in the world of big data, AI, IoT, and smart city system standards. The following benefits of ontology are recognized as important with respect to interoperability, connectivity, traceability of digital content, particularly machine readability, executability and interpretability of digital content for decision making and actions.

– Increase interoperability across domains.
– Enable machine-readable code for computational reasoning and decision making.
– Create semantic linkages between data, information and knowledge systems.
– Build accessible APIs and semantic linkages between web-based data objects.
– Link data domains with shared concepts or canonical data models.
– Connect shared data concepts and definitions between domains.

However, ontology has a variety of definitions in different international standards. How to understand different meanings of ontology and select the right definition for the right stakeholders' concerns for the right purposes is a big challenge for effective integration of business, data, information, knowledge and decision making, across disciplines, domains, systems, platforms and applications in smart cites. Moreover, how to deal with the grand challenges of interoperability of many and various ontologies to satisfy the demands from artificial intelligence and big data analytics are gaps to be filled in the area of smart city systems. How to develop digital content that is machine readable, executable and interpretable, working in the system without human effort for a smart city system are emerging needs to be studied. There are significant demands for better communication, coordination, cooperation, collaboration and connectivity of existing ontology standards to smart cities practical sectors. This document aims:

- to identify existing ontology standards from different Standards Development Organizations (SDOs) and to provide best practice examples and considerations of ontology standards development and maintenance for smart city systems;
- to identify gaps in existing ontology standards for smart city systems and the opportunities and challenges in ontology standards development taking into account multi-dimensional and muti-domain stakeholders' concerns city wide, and to provide recommendations for ontology standards development and maintenance to enable integration, interoperability, efficiency and effectiveness of smart city systems.

SMART CITY SYSTEM ONTOLOGY –

Part 1: Gap analysis

1 Scope

This document provides a gap analysis on ontology relevant standards for smart city systems to be used as a base document for mapping, developing and maintaining a set of ontology standards for smart city systems.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
characteristic
abstraction of a *property* (3.8)

Note 1 to entry: Characteristics are used to describe concepts.

[SOURCE: ISO 1087:2019, 3.2.1, modified – The EXAMPLE has been deleted.]

3.2
concept
unit of knowledge created by a unique combination of *characteristics* (3.1)

[SOURCE: ISO 1087:2019, 3.2.7, modified – The Notes to entry have been deleted.]

3.3
definition
representation of a concept by an expression that describes it and differentiates it from related *concepts* (3.2)

[SOURCE: ISO 1087:2019, 3.3.1]

3.4
digital system
system consisting of hardware, software, and possibly network components, used to generate and/or use data to fulfil one or more specific functions

EXAMPLE 1: A digital traffic system that uses sensors to measure real time traffic movement digitally and sends that data to where it can be collected, analysed and used both to control digital traffic signals and to provide information to support decision making by staff in traffic management roles and by travellers.

EXAMPLE 2: A digital health record system that transforms information related to patients into digital form and enables it to be shared and analysed to support treatment.

EXAMPLE 3: A digital payment system that uses smart cards, readers, and secure data transmission, and sends queries and enables the alteration of data within financial institutions, to allow goods and services to be paid for without the need of cash.

EXAMPLE 4: A digital assembly line system in a factory that collects and monitors data coming from a variety of sources and uses that to coordinate robotic assembly processes and make any adjustments necessary to support quality and efficiency goals.

[SOURCE: IEC 60050-831:–, 831-02-03]

3.5
domain
subject field
field of special knowledge

[SOURCE: ISO 1087:2019, 3.1.4]

3.6
object
anything perceivable or conceivable

Note 1 to entry: Objects can be material (e.g. ‘engine’, ‘sheet of paper’, ‘diamond’), immaterial (e.g. ‘conversion ratio’, ‘project plan’) or imagined (e.g. ‘unicorn’, ‘scientific hypothesis’).

[SOURCE: ISO 1087:2019, 3.1.1]

3.7
physical system
set of physical objects and processes that work together to fulfil one or more specific functions

EXAMPLE Electrical power distribution systems, logistics systems, metro systems.

[SOURCE: IEC 60050-831:–, 831-03-03]

3.8
property
feature of an *object* (3.6)

Note 1 to entry: One or more objects can have the same property.

[SOURCE: ISO 1087:2019, 3.1.3, modified – The EXAMPLES have been deleted.]

3.9
smart city
city where improvements in quality of life, services, sustainability and resilience are facilitated by the effective integration of many and various types of physical, digital and social systems and the transformative use of data and technology

Note 1 to entry: This is a general definition of a smart city. The IEC looks at these aspects from the perspective of electrotechnology.

Note 2 to entry: The effective integration of physical, digital and social systems can be facilitated by integration of digital twins of all these systems.

[SOURCE: IEC 60050-831:–, 831-01-19]

3.10
system
combination of interacting elements organized to achieve one or more stated purposes

Note 1 to entry: In the context of smart cities, the system as a whole exhibits (as the result of interactions between its elements) some emergent characteristics indispensable to achieve one or more of its stated purposes.

Note 2 to entry: In the city transport system the interactions between traffic management and emergency management, sharing information related to resource allocations, road network conditions, video surveillance imaging and control, enable the emergent characteristic of improvement in traffic congestion.

[SOURCE: ISO/IEC/IEEE 21840:2019, 3.1.8, modified – The Notes to entry have been added.]

3.11
social system
patterned series of interrelationships existing between individuals, groups, and institutions and forming a coherent whole

EXAMPLE Nuclear family units, communities, cities, nations, college campuses, corporations, and industries.

Note 1 to entry: An individual can belong to multiple social systems at once.

Note 2 to entry: The organization and definition of groups within a social system depend on various shared properties such as location, socioeconomic status, race, religion, societal function, or other distinguishable features.

[SOURCE: IEC 60050-831:–, 831-04-03]

3.12
system of systems
SOS
<systems> set of operationally and managerially independent *systems* (3.10) that are coordinated together to achieve one or more commonly stated purposes

Note 1 to entry: Each constituent system is a useful system by itself, having its own management, goals, and resources, and coordinates within the SOS to provide the unique capability of the SOS.

[SOURCE: IEC 60050-871:2018, 871-05-03, modified – The domain <systems> has been added. In the definition, "operated" has been replaced by "coordinated", "commonly" has been added, and "for a period of time" has been deleted. Note 1 to entry has been replaced by new Note 1 to entry from ISO/IEC/IEEE 24748-1:2018, 3.56, in which "but coordinates" has been replaced by "and coordinates".]

3.13
term
designation that represents a general *concept* (3.2) by linguistic means

[SOURCE: ISO 1087:2019, 3.4.2, modified – The EXAMPLE and Note 1 to entry have been deleted.]

3.14
terminology
set of designations and *concepts* (3.2) belonging to one domain or subject

[SOURCE: ISO 1087:2019, 3.1.11]

4 Foundations of concept system building for smart city systems

4.1 Methods of ISO 704:2022

An analysis of key terms relevant to ‘unit of knowledge’ and ‘characteristics’ in definitions of smart city is conducted based on understandings about ‘concept’ and ‘characteristic’ in ISO 704:2022 and ISO 1087:2019.

The relations between the ‘object’, ‘property’, and ‘characteristic’ are well described in ISO 704:2022, 5.4.1, which provides a way to identify object and its characteristics that helps define concept.

4.2 Core concepts and the characteristics of smart city by different SDOs

Based on six collected definitions of smart city, a survey was conducted to identify and investigate core concepts and their characteristics in the definitions of smart city from different SDOs during online meetings from 29 April to 14 May 2021. Eight questions, comprising seven closed questions and one open question, were designed in a questionnaire (see Annex A). The questionnaire was sent to experts from IEC SyC Smart Cities through the IEC collaboration platform and to experts of ISO/TC 268/SC 1/WG 4, ISO/IEC JTC 1/WG 11 and ITU-T SG 20 by email. 14 responses to the survey were collected and validated for the analysis.

Table 1 and Figure 1 show core concepts in definitions of smart city from different SDOs and their relationships and common characteristics.

At the high level, characteristics on smart city involves responding to stakeholder concerns and domain-specific concerns. People’s issues and concerns were represented by over 80 % to 100 % agreement from different stakeholders of different SDOs in stakeholders’ concerns. Therefore, placing a citizen-centric focus on smart city development is recommended or might focus on present generation and future generations for its citizens. Stakeholder concerns also include supplying side services to citizens from government and business agencies, especially customers.

In addition, domain concerns refer to diverse city system feature issues of city which can be divided into digital, environmental, economic, cultural and social aspects. Specifically, the digital aspect can involve information technology, digital transformation, electrotechnical systems, data and information. The environmental aspect includes two elements such as the built environment and natural environment, and social aspect refers to international standards and coordinated and reflexive system.

Means and approaches for smart city could be intermediate level to connect high level and low level. Smart city can select from a wide range of policy, leadership and technical use methods which refer to collaborative leadership, disciplines and city system, recognized metrics at society level and ICT, electrotechnical systems, use of data and information from modern technologies.

Smart object, smart status and visions and goals can be identified from definitions of smart cities. In smart object, integration of physical, digital and social systems is possibly the most important feature of smart city which could provide better understanding and benefits for decision makers, development of sustainability and community. Moreover, effective integration is also essential for smart status. Effective integration enables digitally coordinated systems as self-organizing system that accelerate improvement of services, increase pace of learning and reflexing and innovation. Finally, in terms of visions and goals of smart city, what smart city is intending to achieve is defined by improvements of targeted goals. Hence, smart city is not only intended to achieve competitiveness, stability, liveability and resilience, and repeatability and scalability, but also to enhance fundamental improvements on efficiency, concerns addressing quality of life and better city services.

Table 1 – Core concepts and the characteristics of smart city from different SDOs

Characteristics	Concepts		
	ISO	IEC	ITU-T
Characteristics in terms of stakeholder's concern about smart city	• citizen (D1, D3)	• citizen (D4, D5)	• present and future generation (D2)
Characteristics in terms of domain's concern about smart city	• built environment (D1) • natural environment (D3)	• city (D4, D5, D6) • international standards and digital transformation (D5) • electrotechnical systems and information technology (D6)	• economic, social, environmental as well as cultural aspect (D2)
Characteristics in terms of smart object of smart city	• integration of physical, digital and human systems (D1) • city (D3)	• city (D4, D5, D6)	• city (D2)
Characteristics in terms of smart status of smart city	• effective integration (D1) • increasing the pace (D3)	• improvements accelerated (D4) • self-organizing system (D5) • digital transformation as digitally coordinated systems with its own pace (D5) • improvements for services (D6)	• innovative (D2)