



DPC: 23 / 30468266 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Title: BS EN SRD 63476 Systems Reference Deliverable (SRD) Smart city system Ontology

Part 1: Gap Analysis

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Responsible Committee Secretary: **Ms Andreea Vieru (BSI)**
Direct tel: **0208 996 7432**
E-mail: **andreea.vieru@bsigroup.com**

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



SyCSmartCities/273/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

IEC SRD 63476 ED1

DATE OF CIRCULATION:

2023-01-13

CLOSING DATE FOR COMMENTS:

2023-04-07

SUPERSEDES DOCUMENTS:

SyCSmartCities/259/NP, SyCSmartCities/268B/RVN

IEC SYC SMART CITIES : ELECTROTECHNICAL ASPECTS OF SMART CITIES

SECRETARIAT:

IEC Secretariat

SECRETARY:

Mr Gennaro Ruggiero

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:



Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☐ SAFETY

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TITLE:

Systems Reference Deliverable (SRD) Smart city system Ontology -- Part 1: Gap Analysis

NOTE FROM TC/SC OFFICERS:

1 **Smart City System-Ontology-Gap Analysis Report (Working draft)**

2

3 **Version control**

Version	Date	Tracking	Contributors
Version 1	20211007	Whole document is updated consisted by 8 sections for discussion on the next WG1 meeting	Introduction and Section 1, 2, 3 (Xiaomi An) Section 4 (Xiaomi An, Wei WEI) Section 5 (Xiaomi An, Wei WEI) Section 6 (Yu Dong) Section 7.1 (Yanyan Wang) Section 7.2 (Wei WEI, Dapeng Zhang, Hongwei Zhang) Section 8 (Xiaomi An, Yanyan Wang, Wei WEI)
Version2	20211014	Ontology : formal representation of phenomena of a universe of discourse with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their relationships, the foundation of epistemology and methodology, Ontology is materialistic and comes from the summary of practice.	Huaikun,Tang
Version 3	20211105	Introduction to identify existing ontology standards for smart cities and smart city systems from different SDOs; change to to identify existing ontology standards for smart cities and smart city systemss from different Standards Developing Organizations (SDOs); 4.2 Citizen is the vital characteristic which receives 80% to 100% percent agreement from different stakeholders of different SDOs in stakeholder concern. Change to	Yanyan Wang

		People is the vital characteristic which receives 80% to 100% percent agreement from different stakeholders of different SDOs in stakeholder concern. 7.2 To sum up, IEC and JTC use the same definition on ontology and they may describe ontology from terminology and ICT. Change to To sum up, IEC/Sys and ISO/IEC JTC 1/WG 11 use the same definition on ontology and they may describe ontology from terminology and ICT.	
Version 4	20211129	Adding definitions of 'physical system', "digital system" and 'social system' from IEV 60050-831 CDV.	Xiaomi An Wei Wei
Version 5	20220120	1) Updating the sources in Clause 6 2) Updating Annex B 3) Add clause 5.6 and 6.6	Mark Fox, Shuji, Manikandan,K, Xiaomi An, Wei Wei
Version 6	20220310	Revised Clause 5.3 and added Figure 6 Updated Figure 8 Revised Clause 6 and updated W3C sources Updated Clause 6.11 and added Figure 11 Updated Clause 8.3 with Recommendation 3	Xiaomi An, Wei Wei
Version 7	20220319	Updated consistency of wordings and terms used in the whole document Clause 8 was modified Deliverables are modified in Recommendations	Xiaomi An, Wei Wei
Version 8	20220321	Grammatical correction according to Mani's comments	Manikandan Xiaomi An, Wei Wei Dapeng Zhang
Version 9	20220415	Updated according to comments received from the last meeting held on March 23, 2022	Xiaomi An, Wei Wei
Version 10	20220420	Updated introduction in consistent with contents of NP form 4, modified	Xiaomi An Wei Wei

		Clause 6, corrected the mistakes	
Version 11	20220421	Corrected the report according to the meeting notes of April 20 th 2022	Xiaomi An Wei Wei Dapeng Zhang
Version 12	20221111	Corrected the report according to the meeting notes of November 10, 2022 Agreed disposition of comments from national bodies of Japan and China. (DOC. No.4 CC_SyCSmartCities_259_NP (proposed disposition of comments)2022-11-10 R1)	17 participants of WG1 meeting held on November 10, 2022 Xiaomi An (CN , Convener) , Manikandan K. (IN, Convener), Giovanni CAMBRONERO, ANCE AC(MEXICO), Georgi Babinov (SBS), Jing Wu (CN), Mark Fox (CA, JTC1/AHG16 Convener), Ken Vaughn ((ISO TC 204), Joachim Schonowski (DE), Kyoungsook Kim (JP), Amelie Gyrard Trialog (France), Wei Wei (CN), Jinghua Min (CN), Dong Yu (CN), Hongwei Zhang (CN), Yangli Jia (CN), Xiaoshuang Jia (CN), Yangli Jia (CN), Yanyan Wang (CN), Yongchao Gao (CN), Huaikun Tang (CN)
Version 13	20221120	Checked and updated according to Agreed disposition of comments from national bodies of Japan and China and technical report of ontology virtual seminar held on September 22 and September 23. (DOC. No.4 CC_SyCSmartCities_259_NP (proposed disposition of comments)2022-11-10 R1) (Doc.No. 7 SyCSmartCities WG1 R Report of international seminar on ontology 2022-11-07)	Wei Wei, Xiaomi An
Version 14	2022-12-04	Doc. No.5 SyCSmartCities_259e_NP2022-11-20-updatedR 1Dongyu	Yu Dong, Yangli Jia, Xiaomi An

		Doc. No.6 SyCSmartCities_259e_NP2022-11-20- updatedR 1Dongyu jiayangli Checked and updated	
Version 15	2022-12-09	Updated according to Doc. No.3 CC_SyCSmartCities_259_NP (agreed disposition of comments) and Doc. No. 2 SyCSmC WG1_20221208_eMeeting RM Updated all figured using white, black and grey color. Adding explanations to figure14 and figure 15. Updated Figure 15, using latest findings from international virtual seminar on ontology, see Doc.No. 7 SyCSmartCities WG1 R Report of international seminar on ontology 2022-11-07)	Xiaomi An, Yu Dong
Version 16	2022-12-15	Updated figures and adding explanations to the figures	Xiaomi An, Yu Dong , Yangli Jia
Version 17	2022-12-16	Updated figure 16, change color of smart city domain from yellow to grey, correct mistakes in Figure 16 , change ISO30182:2017 to ISO/IEC 30182:2017; Adding contents of ISO/IEC 30182:2017. Checked and updated reference format and order in Appendix B	Wei Wei, Yu Dong, Xiaomi

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FOREWORD

53

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86 The text of this standard is based on the following documents:

Draft SRD	Report on voting
SyCSmartCities/####/Draft	SyCSmartCities /####/RVD

87 Full information on the voting for the approval of this standard can be found in the report on voting
88 indicated in the above table.

89 This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

90 The committee has decided that the contents of this document will remain unchanged until the
91 stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the
92 specific document. At this site, the document will be:

- 93 • reconfirmed
- 94 • withdrawn
- 95 • replaced by a revised edition or
- 96 • amended

97

98

INTRODUCTION

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

103 Increase interoperability across domains

104 □ Enable machine readable code for computational reasoning and decision making

105 □ Create semantic linkages between data, information and knowledge systems

106 □ Build accessible API's and semantic linkages between web-based data objects

107 □ Link data domains with shared concepts or canonical data models

108 □ Connect shared data concepts and definitions between domains

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

119 ● to identify existing ontology standards from different Standards Developing Organizations (SDOs) and to
 120 provide best practice examples and considerations of ontology standards development and maintenance for smart
 121 city systems;

122 ● to identify gaps in existing ontology standards for smart city systems and the opportunities and challenges in
 123 ontology standards development taking into account multi-dimensional and multi-domain stakeholders' concerns
 124 city wide and to provide recommendations for ontology standards development and maintenance to enable
 125 integration, interoperability, efficiency and effectiveness of smart city systems.

126 • .

Systems Reference Deliverable (SRD) 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

3.1

characteristic

abstraction of a **property (3.8)**

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

[SOURCE: ISO 1087:2019, 3.2.1, modified, EXAMPLE is deleted.]

3.2

concept

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

[SOURCE: ISO 1087:2019, 3.2.7]

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 CDV, 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 CDV, 831-03-03]

189

190 **3.8**191 **property**192 feature of an **object (3.6)**

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

194 [SOURCE: ISO 1087:2019, 3.1.3]

195

196 **3.9**197 **smart city**

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

201 Note 1 to entry: This is a general definition of a smart city. The IEC looks at these aspects from
202 an electrotechnical perspective.

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

205 [SOURCE: IEC 60050-831 CDV, 831-01-19]

206

207 **3.10**208 **system**

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

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

213 Example: In the city transport system the interactions between traffic management and emergency
214 management, sharing information related to resource allocations, road network conditions, video
215 surveillance imaging and control, enables the emergent characteristic of improvement in traffic
216 congestion.

217 [SOURCE: ISO/IEC/IEEE 21840:2019, 3.1.8, modified-Note 1 to entry is added.]

218

219 **3.11**220 **social system**

221 patterned series of interrelationships existing between individuals, groups, and institutions and
222 forming a coherent whole

223 EXAMPLE: Social systems include nuclear family units, communities, cities, nations, college
224 campuses, corporations, and industries.

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

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

229 [SOURCE: IEC 60050-831 CDV, 831-04-03]

230

231 **3.12**

232 **system of systems**, <systems>

233 **SOS**

234 set of operationally and managerially independent systems **(3.10)** that are coordinated their work
235 together to achieve one or more commonly stated purposes

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

238 [SOURCE: IEV 871-05-03, modified, “worked” is used to take place of “operated”, “for a period
239 of time” is deleted”; Note 1 to entry is taken place of by new Note 1 to entry adapted from
240 ISO/IEC/IEEE 24748-1:2018, 3.56, ‘and’ is used to take place of ‘but’.]

241

242 **3.13**

243 **term**

244 designation that represents a general concept **(3.2)** by linguistic means.

245 [SOURCE:ISO 1087:2019, 3.4.2]

246

247 **3.14**

248 **terminology**

249 set of designations and concepts **(3.2)** belonging to one domain or subject.

250 [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 shown in Figure 1 which is described in ISO 704:2022, 5.4.1.

The relations between object, property, characteristic and concept can be further elucidated by the following statements:

— each object has at least one property;

— each relevant property is abstracted into a characteristic;

— each concept is comprised of at least one characteristic;

— each object is abstracted into at least one concept

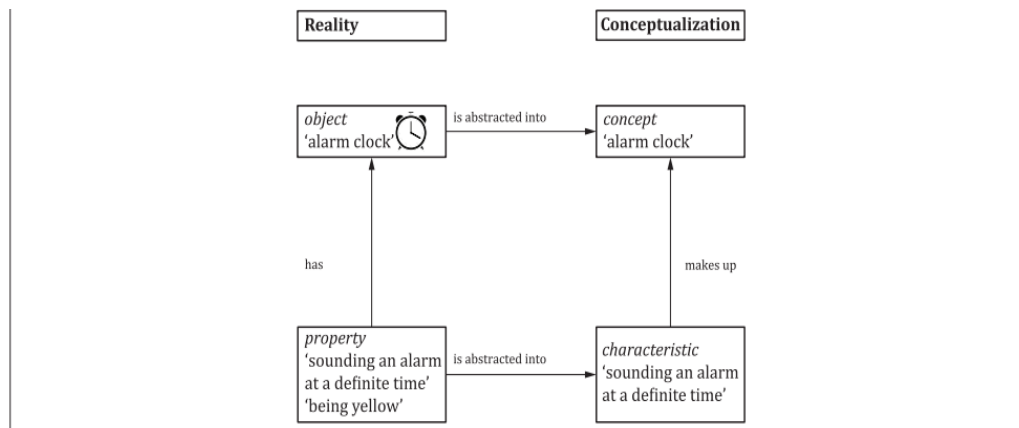


Figure 1 - Relations between the object, property, concept and characteristic

(Source: ISO 704:2022, 5.4.1)

4.2 Core concepts and the characteristics of Smart City by different SDOs

Based on 6 collected definitions of smart city, a survey was conducted to identify and investigate core concepts and their characteristics of smart city from different SDOs during 29th of April to 14th of May online meetings in 2021. 8 questions including 7 closed questions and 1 open question were designed in a questionnaire (See Appendix A). The questionnaire was sent to experts from IEC SyC Smart Cities through IEC collaboration platform and to experts of ISO/TC268/SC1/WG 4, ISO/IEC JTC1/WG 11 and ITU-T SG 20 by emails. 14 feedbacks were collected and validated for the analysis.

Table 1 and Figure 2 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 generation for its citizen. Stakeholder concern also refers to includes supply side services to citizens from government and business agencies especially customer.

In addition, Domain concerns refers to diverse city system feature issues of city which can be divided into digital, environmental, economic, cultural and social aspects. Specifically, digital aspect may involve information technology, digital transformation, electrotechnical systems, data and information. Moreover, Environmental aspects includes two elements such as the built environment and natural environment while 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 may 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 respectively.

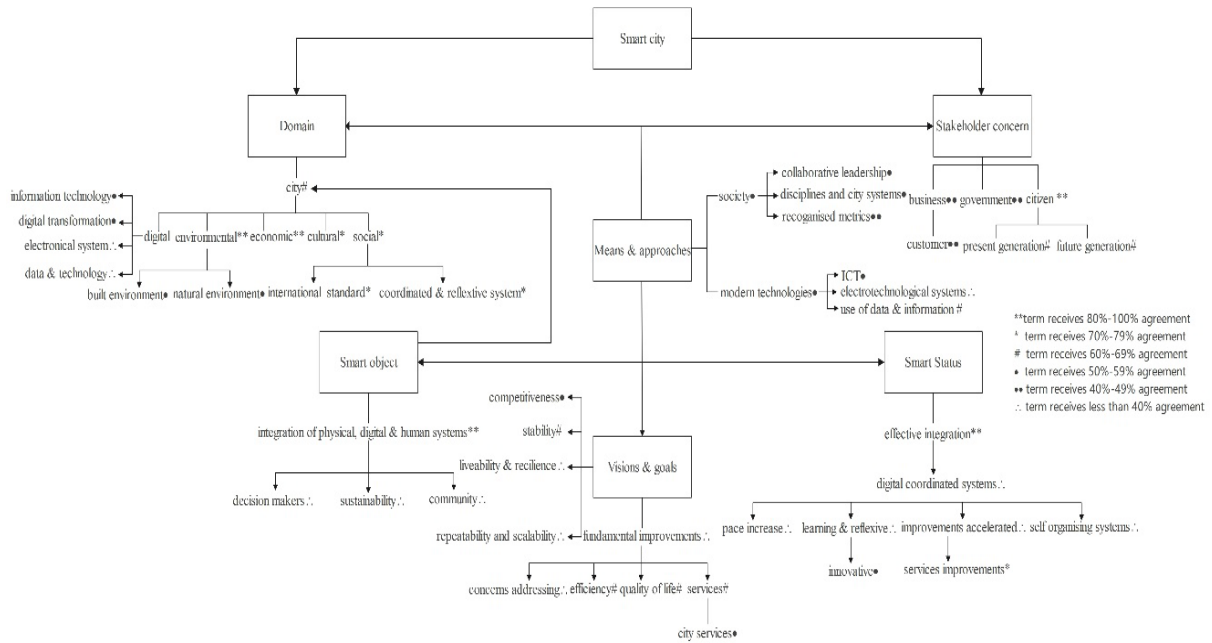
Smart object, smart status and visions and goals consist of low level for smart city conceptual framework. In smart object, integration of physical, digital and social system could be the most important feature of smart city which could provide better understandings and benefits for decision makers, development of sustainability and community. Moreover, effective integration is also essential for smart status. Therefore, it needs digital coordinated systems to fulfill pace increasing, learning, and reflexing then to be innovative, improvement accelerated especially services improvement, self-organizing system. Finally, in terms of visions and goals of smart city, what smart city is intending to achieve are defined by improvements of targeted goals. Hence, smart city not only intend to fulfil competitiveness, stability, liveability and resilience, and repeatability and scalability, but also to acquire fundamental improvements on efficiency, concerns addressing, quality of life and better services especially city services.

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

Concepts	SDOs	ISO	IEC	ITU-T
Characteristics				
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) ● increases 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)
Characteristics in terms of visions and goals of smart city (improvement of targeted goals)	● a sustainable, prosperous and inclusive future (D1) ● fundamentally improving (D3) ● provides social, economic and environmental sustainability outcomes and responds to challenges such as climate of change, rapid population growth, and political and economic instability, to deliver better services and quality of life(D3)	● improvements in quality of life, services, sustainability and resilience (D4) ● repeatability and scalability of digital solutions (D5) ● systematically addressing concerns(D5) ● city services(D6)	● improve quality of life, efficiency of urban operation and services, and competitiveness (D2)
Characteristics in terms of approaches to and means of smart city	● effective integration of physical, digital and human systems(D1) ● engage society applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies (D3)	● by the effective integration of many and various types of physical, digital and social systems and the transformative use of data and technology (D4) ● internationally recognized metrics(D5) ● electrotechnical systems and information technology(D6)	● information and communication technologies (ICTs) and other mean (D2)

308 **Note:** D refer to definition. Dn refers to code of definition.



309
310 **Figure 2 - An integrated concept system on smart city**

311 4.3 System of systems view on smart city system in IEC 63235:2021

312 Figure 3 shows a system of systems view for smart cities and smart city systems according to IEC
313 63235:2021:

314 *A system of systems view (see Figure 3)) considers the smart city as a complex system of*
315 *made up of many vertical domains such as transport, health, education, employment and so*
316 *on. Each of these vertical domains are is interconnect by three cross cutting*
317 *overarching/horizontal systems that includes views aspects of a city centric social system,*
318 *digital system and physical system of a city and system approach, which work together as a*
319 *complementary whole in responding to the concerns and representing the interests of*
320 *different stakeholders (ISO/IEC 30182:2017, 2.14). Each of these, in turn, can be*
321 *subdivided to describe in greater detail into other horizontal, cross-cutting domains.*

322 *Taking this A system of systems view enables the total capability of a city wide view to be*
323 *understood from both a technical domain and societal perspective to be enhanced in a way*
324 *to an extent that none of the constituent system can accomplish on its own. Each constituent*
325 *system is a useful system by itself with has its own management, goals and resources, but*
326 *when coordinated within the smart city systems (SCSs) contributes to provide the unique to*
327 *a broader capability as a member of the SCSs.*

328 *The social system provides a multi-dimensional governance framework (ISO/IEC TR*
329 *38502:2017, 3.1) for coordinating arrangements of strategies, policies, decision-making*
330 *structures and accountabilities to manage multiple stakeholders' needs and wants concerns*
331 *in social space and convergence.*

332 *A digital system provides a multi-domain architectural framework*
333 *(ISO/IEC/IEEE 24748-1:2018, 3.7) for cooperating activities of conventions, principles and*
334 *practices for individual domain architecture and to enable, operate and support digital*
335 *transformation.*

A physical system provides a multi-layer application framework (ISO/IEC/IEEE 24765:2017, 3.177) to connect identify and sustainably manage artefacts in each subsystem and enable interfaces between systems in physical spaces to support all necessary interactions.

An integration of the social, digital and physical systems with technical domains supports the convergence of multi-dimensional, multi-domain and multi-layer concerns and interests can aid the mapping and coordination of digital systems development, design and operations to support smart city of multiple stakeholders as well as enhancing the adaptive capacity of a city as an ecosystem to deliver a sustainable, prosperous and citizen centric futures. inclusive future for its citizens

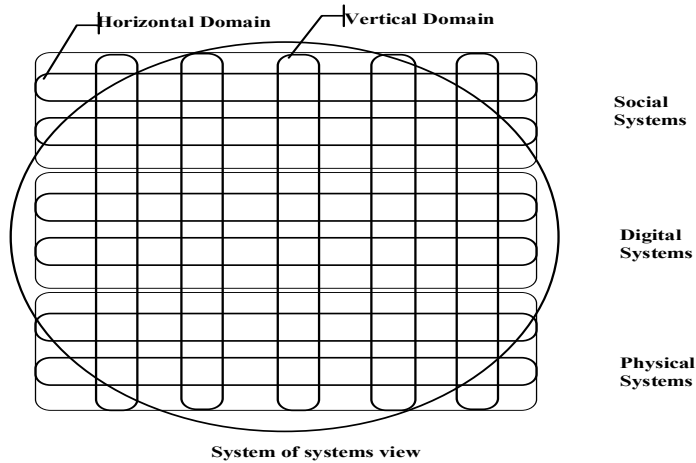


Figure 3- Concept views of smart city systems

(Source: IEC SRD 63235 2021, Figure 1)

4.4 Methodology framework for smart city system concept in IEC 63235:2021

Figure 4 shows a methodology framework for smart cities and smart city systems according to the IEC SRD 63235: 2021:

A methodology framework refers to a way, or structure, that supports a number of supporting different methods and languages to be used can together be used to effectively when developing a complex multi-domain level system.

The methodology framework for a smart city system concept system refers to a system of systems way of thinking that supports multi-dimensional, multi-domain and multi-layer, lifecycle and use case analysis approaches to be used together as a complementary whole in developing a smart city system.

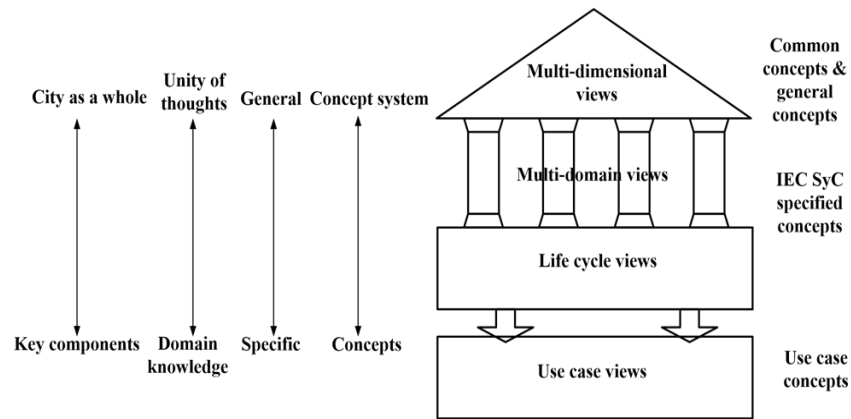


Figure 4- A methodology framework for building smart city system concept

(Source: IEC SRD 63235:2021, Figure 2)

4.5 Descriptive framework of city in ISO 37105:2019

ISO 37105:2019, Sustainable cities and communities-framework for cities and communities (see figure 5) presents a descriptive framework of city and a foundational ontology related with basic elements of a city, including social system dimension, physical system dimension and human-machine interaction in digital system dimension. Specifically, the descriptive framework refers to the following characteristics:

- Cross-time which has inclusiveness with various human habitants in any historically periods;
- Cross-culture which has adaptability on any culture and any types of cities;
- Extensional which can be either used for super scale cities or used for middle and small cities, towns or rural areas.
- General which has adaptability on any places where are defined as “human habitants”, such as “smart city”.

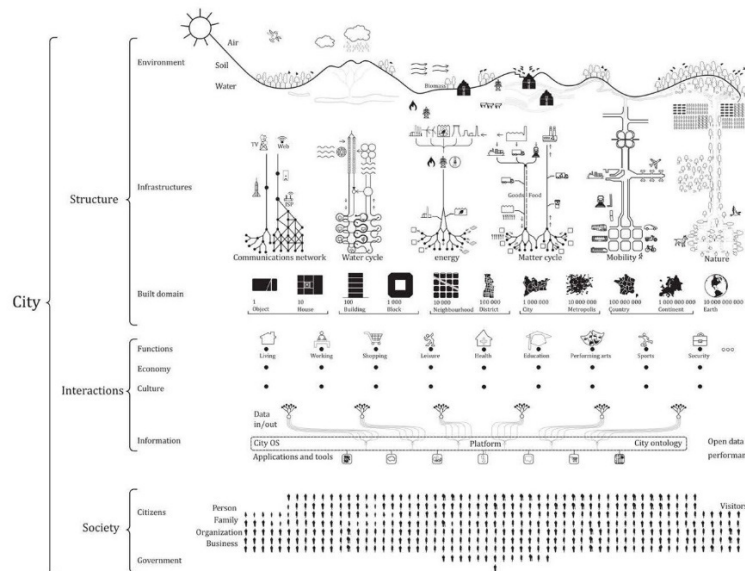


Figure 5 – A descriptive framework for building a city system

(Source: ISO 37105:2019, Figure 1)

5 Existing ontology definitions from different SDOs

5.1 Existing ontology definitions from different sources

15 definitions existing in different SDOs were collected and analysed at the *Ontology for Smart Cities and Smart City Systems & Standards Workshop* held by IEC SyC Smart Cities, September 30, 2020. Furthermore, 8 additional definitions from different authoritative sources are added from this ontology workshop. Totally, there are 23 definitions of ontology collected as samples for analysis (See Appendix B).

5.2 Methodology for identification of concepts and concept relations

Methodology for identification of concepts is in conformity with ISO 704:2022 and the basic processes for identification of concepts and its relations is shown in Figure 6:

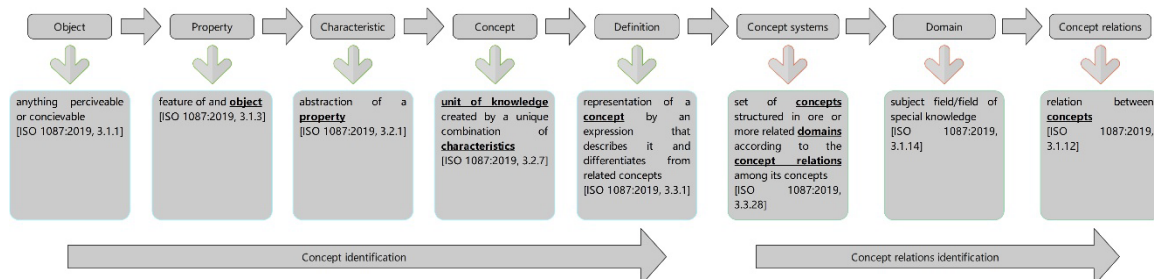


Figure 6 - Basic process for identification of concepts and their relations

(Source: Adapted from ISO 704:2022 and ISO 1087:2019)

First of all, Concepts are described to distinguish them from others and relationships are also described between them based on past domain specific knowledge. In order to describe the concept and distinguish from other related concepts, the definition can be used to represent the concept. After that, in order to identify the concept relation, the concept system is structured by set of concepts which are related to domain and knowledge.

In addition, ISO 704:2022,5.5.3 presents 3 types of concept relations which are generic relation, partitive relation and associative relation (See Table 2).

Table 2- Three types of concept relations

No	Types of concept relations	Definition
1	generic relation	concept relation between a generic concept and a specific concept where the intension of the specific concept includes the intension of the generic concept plus at least one additional delimiting characteristic Note 1 to entry: Outside the terminology community, “type-of relation” and “is-a relation” are also used instead of “generic relation”. Note 2 to entry: In a generic relation the subordinate concept is a specific concept and the superordinate concept is a generic concept. [SOURCE:ISO 1087:2019, 3.2.13]
2	partitive relation	concept relation between a comprehensive concept and a partitive concept [SOURCE:ISO 1087:2019, 3.2.14]
3	associative relation	associative relations are non-hierarchical. An associative relation exists when a thematic connection can be established between concepts by virtue of experience [SOURCE: ISO 704:2022, 5.5.3]

5.3 Concept and concept relations about ontology

Ontology concept refers to three key components: Terminology, Subclass of and Logic (TSL).

(1) Terminology refers to entities with attributes and relations with optional domain and range specifications;

(2) Subclass of refers to addition of taxonomic relations;

(3) Logic refers to addition of definitions using a formal language, this level involves description logic that has restriction

Therefore, 6 types of concept relations in existing definitions of ontology are identified shown as below mapping with TSL viewpoint (See Table 3):

Table 3 - Types of ontology concept relations

No	Types of ontology concept relations	TSL analysis	Description of concept relations	Source (See Appendix B)
----	-------------------------------------	--------------	----------------------------------	----------------------------