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Smart community infrastructures — Urban data integration framework for smart city planning (SCP)

Infrastructures urbaines intelligentes — Cadre d'intégration des données urbaines pour la planification des villes intelligentes

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Foreword

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This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*, Subcommittee SC 1, *Smart community infrastructures*.

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Introduction

The city is a product of social evolution, technology, economic and social civilization improvements, as well as a fundamental unit for the social and economic life of its region. However, with the influence of global urbanization, increasingly more problems have been observed, such as environmental pollution, traffic congestion, insufficient resources and urban lifeline system weakness.

Urban planning refers to the conduct of engineering construction, economy, society, environment and land use of the city and its surroundings. It involves the regional layout of industry, the regional layout of buildings, the setting of transportation infrastructure and the planning of urban engineering. It is related to urban development and city infrastructure construction.

The planning, construction, operation, management and evaluation of community infrastructure is the process of natural environment transformation. This process involves multiple city managers and various data. Therefore, the integration of heterogeneous data for smart community infrastructure planning is particularly important. Based on ecological and spatial information, the smart city planning (SCP) data and infrastructure data that need to be integrated should be analysed. The establishment of a data integration framework and further realization of heterogeneous data integration is intended to support the operation of community infrastructure construction projects throughout their life cycles and ultimately achieve inclusive, sustainable and high-quality development of the city.

In terms of smart community infrastructure, ISO/TS 37151 describes the principles and requirements of performance metrics. ISO/TR 37152 gives possible issues and solutions in developing and operating smart community infrastructure, outline and benefits of a common framework for development and operation. In addition, BS/PAS 183 provides data interoperability, types of data, data protection reform, data value chain, purposes for data use, assessing data states, access rights for data and data structure.

ISO/TS 37151, ISO/TR 37152 and BS/PAS 183 provide the basis and guidance for ISO 37156, which describes the types and model, opportunities, privacy and security of data exchange and sharing, and provides guidance for data exchange and sharing of smart community infrastructure. ISO 37156 provides guidance for the integration of infrastructure data in this document, and this document is considered to be an application scenery of ISO 37156 in data integration.

Smart community infrastructures — Urban data integration framework for smart city planning (SCP)

1 Scope

This document establishes a data framework that involves possible multi-source common data through standardized data integration and sharing mechanisms. It includes recommendations for:

— precision, dimensions of the data, data collection, updates and storing mechanisms;

— a data model for data integration, data standardization and data fusion approaches for heterogeneous smart city infrastructure data;

— a data security level and sharable attributes for all involved data, principles on data sharing or exchange.

This document focuses on the integration and application of heterogeneous data from urban infrastructure systems, such as water, transport, energy, drainage and waste, so as to support smart city planning (SCP). It contains case studies, in Annex A, of various smart city projects.

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 terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
data
reinterpretable representation of information in a formalized manner suitable for communication, interpretation or processing

Note 1 to entry: Data can be processed by humans or by automatic means.

[SOURCE: ISO/IEC 2382:2015, 2121272]

3.2
data availability
property of being accessible and usable upon demand by an authorized entity

[SOURCE: ISO/IEC 27000:2018, 3.7, modified — term revised.]

3.3
data exchange
accessing, transferring, and archiving of *data* (3.1)

[SOURCE: ISO/TS 13399-5:2014, 3.7, modified — definition revised.]

3.4
data sharing
reference for providing shared, exchangeable and extensible *data* (3.1) to enable urban infrastructure service

[SOURCE: ISO 37156:2020, 3.3.6, modified — definition revised.]

3.5
data type
defined set of *data* (3.1) objects of a specified data structure and a set of permissible operations, such that these *data* (3.1) objects act as operands in the execution of any one of these operations

[SOURCE: ISO/IEC 20546:2019, 3.1.12, modified — Notes to entry removed.]

3.6
heterogeneous data integration
optimization method to enable effective and transformative use of data and technology from multi-source to support sustainable development of cities and to improve the management and control of space and resources

3.7
information
data (3.1) in context with a particular meaning

[SOURCE: ISO5127:2017, 3.1.1.16, modified — definition revised.]

3.8
information resource
asset
record
<set of data> document or item in physical or digital form that contributes to human knowledge

EXAMPLE Abstracting and indexing database.

Note 1 to entry: Information resource sometimes has a broader meaning, including information content, and also technology resources, human resources and financial resources that enable information content management.

[SOURCE: ISO 5127:2017, 3.1.1.44; modified — definition revised and Note 2 to entry added.]

3.9
life cycle
<of a system, product, service, project or other human-made entity> evolution from conception through to destruction or recycling

[SOURCE: ISO/IEC/IEEE 15288:2015, 4.1.23, modified — definition revised.]

3.10
security
condition that results from the establishment and maintenance of protective measures that ensure a state of inviolability from hostile acts or influences

[SOURCE: IEC Guide 120:2018, 3.13]

3.11
smart community infrastructure
community infrastructure with enhanced technological performance that is designed, operated and maintained to contributed to sustainable development and resilience of the community

[SOURCE: ISO 37156:2020, 3.1.4]

3.12
smart city planning
SCP
technical and political process concerned with the development and design of land use and the built environment, which are enhanced by the effective and sustainable integration of informational, physical and social systems and the transformative use of heterogeneous data and technology

3.13
system
set of interrelated or interacting functions constituted to achieve a specified objective

4 Principles

4.1 General

4.1.1 General

The data gathered and to be integrated for SCP should meet some general principles so as to ensure the validity of the following data integration process.

4.1.2 Data availability

The data to be integrated for SCP comes from various sources, some of which are private and classified prior to any data-sharing agreements. Thus, the description of shared data in terms of, for example, attributes, dimensions and volumes should be available to associated integration subjects (described in 6.2), so as to determine whether the shared data are truly available for the intended data integration purpose.

4.1.3 Sovereignty over the data

The ownership of the source data needs to be respected during the whole data integration process among associated stakeholders.

4.1.4 Data security

The data to be integrated for SCP should be secured during the data integration process, from data retrieval, data clean, data storage and data output.

Regional and national security requirements such as the EU General Data Protection Regulation shall be considered. Based on ISO/IEC 27000, considering domestic regulations and technological conditions, an information security management systems (ISMS) or alternative necessary data security procedure and tools should be introduced to deter possible hacker attacks and other misapplication.

The data exchange should therefore be kept to a minimum and a low level of detail. Security-relevant data for planning, constructing, operating and managing of infrastructures should basically remain with the data-collecting organization, ordinarily the utilities.

4.1.5 Data privacy

The data from community infrastructure to be integrated for SCP usually contains private information, from individual socio-economic characteristics to spatial-temporal behavioural data. Integrating and further analysing these individual-based data help to evaluate and optimize urban system performances. But individual privacy should be respected.

The use of source data during the whole integration process should be kept on an anonymous basis. The integration of individual data, for example consumer consumption data, should be pre-desensitized, without personal information being exposed to either data integration engineers or terminal users.

4.1.6 Co-construction and sharing

It is possible that an intended data integration requires data from different agencies or stakeholders. It is recommended that the necessary data are co-constructed and shared among them on a voluntary basis. In addition, the integration results should be shared with contributors.

4.2 Principles of heterogeneous data integration

4.2.1 General

In practice, the multi-source data used for data integration varies in format, dimensions, accuracy and durability. Although data integration approaches are evolving with more recognition or explanation power, it is not usually encouraged to spend huge amounts on retrieving missing data. Depending on the availability and intended use of data, it is recommended that the data integration framework applies the following principles of heterogeneous data integration.

4.2.2 Unambiguity

The definitions and categorizations of entities should be clear where reasonably possible and available. Categorization should be representative and mutually exclusive.

4.2.3 Scalability

Urban data integration requirements and process are continuously updating. The integrated data need not be thoroughly completed and comprehensive in the beginning, but it is recommended that the integration results are flexible and scalable.

4.2.4 Compatibility

Data standards applied in the data integration framework shall be compatible with existing major urban data standards.

4.2.5 Modularity

It is recommended that data integration input, output and approaches or algorithms are defined as modular components, so as to be used individually or in combination for different integration purposes.

In addition to unambiguity, scalability, compatibility and modularity, the urban data integration framework should also have extensibility and interpretability. Maintaining a high level of interpretability is vital during the integration process as the goal is to support the urban design and operational decisions by municipal officials, policymakers and engineer technical staff. A useful urban data integration framework should be capable of integrating heterogeneous data in an extensible (to multiple urban systems), scalable (to the growing amounts of quickly changing urban data streams) and interpretable manner (such that it can inform decision-making).

4.3 Data quality recommendations

On the basis of ISO 19157, the following recommendations are dependent on the intended use of data. For example, zonal plans can be acceptable with a tolerance of several metres but plans for individual buildings might require an absolute positional accuracy of a few centimetres. The quality recommendation of a variety of planning data database results should ensure locational accuracy, attribute accuracy, completeness, logical consistency, geographic quality and data relationality as far as the data are available and it is even possible to determine such data.

a) Locational accuracy. It is recommended that the location given in the data satisfies data requirement in terms of geographic accuracy.

b) Attribute accuracy. It is recommended that attribute values given in the data match the actual values in the real world to the extent required by the expected use. For example, no building should be classified as a pavement, but it can sometimes matter less if a building is classified as residential when it is in fact partly commercial.

c) Completeness. It is recommended that the number of missing or excess data items in the data set, in comparison to the real world, are suitable for the intended use. For example, all planning data should contain exactly the same number of plans as actually exist, but it might not be too important if a zonal plan contains slightly more or fewer building features.

d) Logical consistency. It is recommended that the data are logically consistent with the requirements, in terms of concept consistency, value domain consistency and topology consistency. For example, no plan should be described as agreed if it is only proposed; it is unlikely that a road would not have a postal address.

e) Geographic quality. It is recommended that the geometry of the data conveys the actual data correctly. For example, buildings are defined as polygons instead of a point when the intended use is to correlate retail shops with a metro station spatially; the boundaries of adjacent polygon entities coincide.

f) Data relationality. It is recommended that entities being referenced by different data sources are mapped and related to other entities through the data model defined in the data integration framework.

It is also noteworthy that low-quality data can still be relevant and used to identify or understand the urban environment and phenomena that are poorly documented, but high-quality data allows for more accurate decision-making.

5 Data of SCP on community infrastructure

5.1 General

Community infrastructure is the fundamental safeguard for residents' lives and city development. It incorporates various equipment and systems which are utilized for economic and social activities. Urban infrastructure is still promoting living and economic development, but its impact on ecosystems cannot be ignored. Technology conditions and functional loads can affect the operational efficiency of the social and economic system and also the living quality of residents. Therefore, scientific and reasonable urban infrastructure planning is essential to maintaining urban ecological security and health.

The scientific infrastructure planning of smart cities requires data support, including community infrastructure data and SCP data. SCP data are numerous and diverse and need to be reasonably described and classified. At the same time, community infrastructure data are a core part of SCP data. Further describing the composition, definition and source of community infrastructure data is particularly important for the implementation of the SCP. In addition, further clarification of the usage of infrastructure data is needed, providing support for SCP.

5.2 Usage of community infrastructure data

5.2.1 Construction project life cycle

Integrating of relevant community information resources based on the SCP data, including current situation data, planning, data, administrative approval data and spatiotemporal big data, to realize the entire life cycle of engineering construction projects of data exchange and sharing. Throughout the entire life cycle of the engineering construction project, including planning, design, construction, management and operation, the science of decision-making can be improved, and management efficiency can be improved.

5.2.2 Urban simulation

By integrating SCP data, the distribution, scale, related activities, performance indicators and other attributes of community infrastructure can be described and used in urban planning. In order to understand the internal mechanism of urban system operation, city simulation can be performed after finding out the cause of urban problems and assessing system performance.

5.2.3 Smart transportation

Infrastructure data based on transportation can support the overall control of the transportation field and the entire process of transportation planning and management. As a result, transportation systems have the ability to sense, interconnect, analyse, predict and control cities. In addition, it can fully ensure traffic safety, make use of the effectiveness of transportation infrastructure, improve the efficiency and management level of the transportation system, and serve the smooth development of public transportation and sustainable economic development.

5.2.4 Smart grid

By integrating electricity and ICT data, real-time data collection, transmission, sharing and dynamic monitoring can be achieved, which can enhance the scientific city and rationality of power consumption, such as power consumption and transmission. The smart energy infrastructure has brought great benefits to urban economic development, energy production and utilization, and environmental protection.

5.2.5 Smart environmental sanitation

By integrating the distribution of waste transfer stations, the status of waste bins and ICT data, real-time monitoring of environmental health services, such as infrastructure resource management, waste collection, transportation, disposal and separation, can be achieved. This reduces the cost of sanitation operations and supervision, improving the efficiency and quality of sanitation operations, and ensures the cleanliness and orderliness of the urban appearance.

5.3 Smart city planning (SCP) data

This subclause presents and explains data that are useful in SCP practices. The data dimension can be larger than community infrastructure data. The purpose is to clarify the location and connection of community infrastructure data in SCP data.

Table 1 describes the classification and association of SCP data. As shown in Table 1, SCP data consists of current situation data, urban planning data, administrative approval data and spatiotemporal big data. Current situation data illustrates the current objective status of a city, including natural environment data and built environment data (e.g. buildings, parks, bridges). Urban planning data are thematic data on urban internal planning. Administrative approval data refers to data generated by government administrative approval service. Spatiotemporal big data, such as traffic flow and economic flow, is a new type of data, which is very useful for urban planning. This new type of data is playing an increasingly important role in the planning, management and supervision of urban planning. Current situation data are the basic data for urban planning; furthermore, urban planning data are an important basis for administrative approval. Data generated by plan management provides guidance for city construction, management and sustainable development. Current situation data, planning data and administrative approval data are related to spatiotemporal big data, but related content gives priority to the classification of spatiotemporal big data. Spatiotemporal big data are the focus of attention and represent an important development direction of smart community infrastructure planning. Because of their high frequency and large data volume, spatiotemporal big data require unique methods for data integration.

Table 1 shows more details of SCP data and give examples of what the data are. These descriptions are not exhaustive or mutually exclusive.

