Smart cities standardization: problems and prospects

Ya A Shchenikov and A I Mitiaeva
Saint-Petersburg State University of Aerospace Instrumentation, Bolshaya Morskaya Street, 67, Saint-Petersburg, Russian Federation

E-mail: yar2409@mail.ru

Abstract. The issues of smart cities standardization from the point of view of metrological assurance are considered. The identified standardization problems associated with the complexity of measuring the smart city subjective indicators are described. The arising difficulties in managing a smart city in order to achieve a positive synergistic effect are shown. A forecast was made regarding the possible smart cities standardization directions: metrological assurance, a smart city as a cyber-physical system, individual indicators.

1. Introduction

The concept of a smart city is aimed at improving the quality of its inhabitant’s life through the positive synergistic effect from the implementation and effective operation of its smart subsystems: smart urban environment, smart transportation, smart buildings, smart inhabitants, smart economy and smart management. Smart cities are cities that are developed and comfortable for work and living, adapting to the needs of inhabitants. In a smart city, infrastructure becomes more flexible, efficient and sustainable through the measurement and use of information, digital and telecommunications technologies.

Smart cities projects exist and are being developed in many countries. India has a «One Hundred Smart Cities» program. Since 2002, the Songdo smart city project has been implemented in South Korea. The United States is developing its cities to be smart in terms of urbanization, security, technology, and governance. For example, in New York, about 14 programs have been implemented in these areas. The PRC pays attention to smart people and their interaction with the executive branch. The PRC develops smart cities at the expense of educated young people, thanks to which they immediately respond to their urgent needs. Since 2021 «Toyota Motor» company, in collaboration with a number of other Japanese high-tech companies, plans to start building a prototype smart city in Japan. The UAE has built a small experimental Masdar city with smart infrastructure, by 2025 Saudi Arabia plans to implement the first phase of the Neom smart city construction [1,2].

2. Standards for future smart cities

In recent years, many aspects related to smart cities have been actively standardized by international and local standards organizations. In the European Union, these standards are actively developed by the technical committee TC268 of the international organization for standardization ISO [3,4]; the British Standards Institution BSI standards are also known [5...7]. The criteria of the ITU and the United Nations Economic Commission for Europe are also related to the smart city. In the Russian Federation, there are already standards developed by the Ministry of Construction, Housing and Utilities, also the technical
committee TK194 has released a series of preliminary standards related to the information technology of smart cities [8].

3. **Standardization problems of future smart cities**

3.1. *Problem 1. How to minimize the subjectivity of comfort criteria based on public opinion?*

Existing smart city standards cover objective quality criteria. However, following its concept, a smart city should become the most convenient for the population. It means that it is necessary to monitor the indicators of comfortability of inhabitants. Several main directions of subjective criteria of comfort can be distinguished:

- economic: compliance of the level of services provided with the level of income of the population; the ability of the housing stock and labor exchange to meet the needs of the inhabitants; the correspondence between the volume of public goods and the inhabitants;
- demographic: balanced age and sex structure;
- social: comfort of living, a sense of security, opinion on the level of social services;
- cultural: public interest in various arts, sports, etc.; the ability to meet the needs of the population in cultural venues; a wide range of directions;
- ecological: the level of comfortability of the population with the ecological situation, the number of green zones, etc.

3.2. *Problem 2. How to collect (measure) and process information?*

Smart cities need smart inhabitants. To function effectively for a smart city infrastructure, it is necessary that inhabitants not only know about it, but also know how to use it. If this condition is met, the collected data will be as accurate and objective as possible for their further processing and interpretation.

Where and how to measure subjective criteria of smart cities comfort? How to find out the people opinion about all important directions and details?

Two ways can be distinguished: through direct contact with the population (surveys) and using data provided by available information resources.

In the first method, for the most effective surveys, they should be compiled in a simplified format and placed in places that enjoy great attention of the audience, which will allow you to receive the most complete and relevant information. For example, at an early stage of building an area, when viewing and buying apartments, you can assess the level of income of the population, determine and guide the development of age and sex composition, and determine the needs of future inhabitants in the sphere of services and education. In the future, the data can be refined using surveys in regularly used applications and on websites: utilities, maps, clinics, schools, additional education, etc. Considering narrower areas: you can ask about the disadvantages of transport and the most convenient routes at smart stops and when connecting to a wireless Wi-Fi network at a specific station (now general polls are used).

When the second method is using, it is necessary to collect statistical data, preferably corresponding to each question of the first method: the price range of the most popular apartments, which routes people use, which public places are the most popular? To obtain this data, city and Internet monitoring systems are used: cameras, sensors at the entrance / exit in public places, website traffic ratings, etc.

As a result, two types of data will be collected: the results of surveys and statistical indicators corresponding to the questions. Their combination will allow to reveal the situation in the area in order to identify its problems.

What standardized information processing methods to apply and how to visualize the obtained results?

After the survey, it’s necessary to transform the data. This process includes identifying and removing errors, encoding data and providing them in tabular form. To work with questions that affect a smaller amount of data, a simple tabulation is used (the most used route of urban transport). Cross-sectional tabular is used for more complex assessments (age and sex composition of the population). Further, the
calculation of average values and frequencies, correlation and regression analyzes, analysis of relationships, differences and relationships, forecasting are carried out. The obtained data are visualized in the form of histograms, distribution polygons and diagrams for the district administration, developers and city services.

3.3. Problem 3. How to respond to changing data?
A «smart» city can be viewed as an automatic control system (figure 1).

![Figure 1. Smart city as an automatic control system.](image)

The object of management of a smart city in the operational sense is smart infrastructure. The control device is a smart municipality, which should be supported by artificial intelligence and smart inhabitants. But the feedback in such a system is quite complex. Several feedback loops are required: the current transport infrastructure situation, the current environmental situation, etc. By receiving operational measurements, the smart municipality is able to resolve operational problems. But not all problems can be resolved promptly, even in a smart city. It is impossible to quickly reduce industrial emissions. Therefore, the smart city system should also have feedback loops with a long time delay. Forecasting can increase the efficiency of decision making. This requires the development of a smart city digital twin. This will turn a smart city into a complex cyber-physical system, which will do the analysis of such a system more complicated.

3.4. Problem 4. How to maximize the positive synergistic effect at the level of the system and supersystem?
Any city is a complex socio-technical system, which, according to the systemic approach, has a supersystem and subsystem. The development of one of the subsystems can lead to stagnation of other subsystems of the smart city. The super-system in the form of a state or the world community also has such problems as: competition with other smart cities, the struggle for resources. How to ensure smart cities uniform development in the smart world?

4. Prospects for standardizing smart cities of the future
Smart city standardization aims at the collaboration of smart systems, smart people and smart governance. It defines the subjective comfort criteria and the ways of its correct assessment, i.e. reveals the population needs, controls the process of collecting and processing information about these criteria. Standardization also indicates the ways of a possible reaction to a constantly changing situation on the part of a subsystem or supersystem of smart cities – the use of forecasting and risk management.

4.1. Standardization of smart cities as a complex socio-technical system
A smart city can be in one of three possible states: development, sustainable, stagnation. Maximizing the inhabitants comfort on the one hand can degrade the smart city energy efficiency on the other side. Some compromise can be reached by using a generalized indicator. But when the generalized indicator
is used, the classical problem of particular indicators significance determining appears. Considering that smart cities are in their early stage of development, it is possible to determine the individual indicators significance only with the help of subjective expert methods.

4.2. Standardization of smart cities as a cyber-physical system
Considering the smart city as a cyber-physical system, one cannot but consider such an element as the digital twin. Since it is planned to widely use artificial intelligence systems and mathematical / simulation models in smart cities control systems, it is necessary to understand what model types to use and at what levels to model smart cities.

4.3. Standardization of smart cities in terms of measuring objective and subjective indicators
How to take smart measurements in a smart city? To measure objective indicators, sensors connected in networks – sensor networks can be used. But sensor network technologies are currently still in development. Therefore, research and standards for sensor networks interfaces, techniques for rational placement of sensors are needed. Measuring the smart cities subjective indicators requires to standardize their measurement methods. A system of indicators should be built from individual subjective and objective indicators, which will require individual indicators significance (weights) standardization.

5. Conclusions
Many questions of smart cities standardization are still open [9]. For smart cities, mutually exclusive criteria for comfort and energy efficiency are important. On the one hand, comfort requires energy, on the other hand, to achieve energy efficiency requires the sacrifice of comfort. Therefore, when standardizing, it is important to determine the priority and significance of these criteria.

Some of smart city indicators can be determined by objective methods based on the results of direct measurements, for example: loading of transport infrastructure, NO₂ concentration. Subjective indicators, however, require the development and standardization of their measurement methods. In addition, the measurement of subjective parameters is obviously difficult to automate, which can reduce the smart city intellectual level.

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