ART & TECHNOLOGY PUBLISHING PTE. LTD.

Smart Construction Research

2023 Volume 1, Issue 1

ISSN: 2529-7740

Initiatives and Current Issues of Smart City Development in the IoT Era

Hironobu Azuma*

The Japan Research Institute, Limited., Tokyo 141-0022, Japan

Corresponding author: Hironobu Azuma, hironobu.azuma@gmail.com

Abstract

In Japan, various efforts are being made by both the public and private sectors to respond to the Fourth Industrial Revolution, digital transformation, super cities/smart cities, and other initiatives as part of policy measures. Since the declaration of the pandemic, there has been an inevitable transformation in people's lifestyles and economic activities worldwide, making it increasingly necessary to accelerate these initiatives. In other words, the pandemic shock is causing paradigm shifts in various fields. Furthermore, the government established the Digital Agency on September 1, 2021, with the mission of swiftly and strategically implementing administrative tasks related to the formation of a digital society. As a key strategy for regional revitalization, they have introduced the "Digital Rural City State Concept" to promote the implementation of digital and smart cities from the "regions." This article provides an overview of the ongoing smart city initiatives in Japan and discusses the current challenges.

Keywords

Smart city
Society 5.0
Urban OS (data federation infrastructure)
Well-being
Application programming interface
Architect
Finance scheme
Evidence-based policy making
Sustainability

1. The trends in smart city policies

The concept of a "smart city" has existed for a long time, and until now in Japan, discussions have mainly focused on optimizing fields such as "energy" and "transportation." Currently, smart city policies have been restructured with a focus on "citizens (users)" and incorporating elements of "digital transformation (DX)" and "green transformation (GX)."

This chapter provides an overview of the global trends in data policies and smart city policies (**Figure 1**). Since the commercialization of the Internet in 1995, information and communication technologies (ICT), especially advancements in transmission speed, have led to socialization, mobility, and autonomy, transforming industrial structures to the extent that it is now referred to as the Fourth Industrial Revolution.

During the 1970s and 1980s, legislation was enacted in many countries to protect personal information and ensure privacy, but after 1995, major developments emerged in data policies. Around 2000, countries worldwide began to examine regulatory frameworks for "cross-border data issues," and ongoing revisions of their national data policies were also considered. In 2010, "open data" initiatives were promoted in various countries, and organizations such as "Code for", a non-profit organization that aimed to solve local issues using IT technology, were established. Civic tech initiatives, where citizens use technology to address local and everyday issues, gained momentum. Internet of Things (IoT) sensors and cloud technologies became more affordable, leading to the collection of data from citizens through mobile devices, contributing to the democratization of data. Around 2015, the policies previously in place were integrated into what is now referred to as "smart city policies".

In 2015, the United States launched the Smart City Initiative, while Europe introduced the Digital Single Market (DSM), marking the beginning of digital and smart city policies. China announced the One Belt, One Road initiative in 2013, followed by the Digital Silk Road initiative in 2015. India based its efforts on the Adhaar Project, which started in 2009, and introduced India Stack in 2016. Currently, international competition in the field of digital and smart cities is accelerating. However, international collaboration is also considered important. In the "Osaka Declaration" at the G20 summit held in Osaka in June 2019, leaders from 20 countries and regions encouraged networking and experience sharing among cities for smart city development to promote innovation and foster strong global economic growth. In October of the same year, the Japanese government and the World Economic Forum jointly established the "G20 Global Smart Cities Alliance (GSCA)." Subsequently, the world experienced the pandemic shock, but efforts related to smart cities, including pandemic countermeasures, continue to be shared and discussed among countries.

The "Integrated Innovation Strategy 2019" positioned the realization of "Society 5.0 through the Smart City Concept" as a core strategy. Society 5.0 is defined in the "Fifth Science and Technology Basic Plan" by the Cabinet Office as a "human-centered society that reconciles economic development and the resolution of social issues through highly integrating cyberspace (virtual space) and physical space (real space) systems." In the "Basic Policies for Economic and Fiscal Management and Reform 2021" approved by the Cabinet on June 18, 2021 (known as "Kotai no Hoshin 2021"), it was stated that smart cities should be established in 100 regions by FY2025. This has become a pillar of Japan's growth strategy and regional revitalization strategy, with relevant government ministries and agencies working together (**Figure 2**). Nevertheless, it is essential to note that smart cities are merely a means of implementing the vision of Society 5.0, which is a human-centered future society.

The essence of a smart city lies in realizing a sustainable, self-reliant, and decentralized society designed with a citizen-centered approach, harnessing the unique characteristics of each region to enable people to lead happy and prosperous lives. The ultimate goal is to improve people's well-being, which means they should be in a state of fulfillment in all aspects – physical, mental, and social. To achieve this outcome, the use of cutting-edge technologies like ICT and artificial intelligence (AI), as well as data utilization, is essential, and this is the true purpose of promoting DX.

In Japan, three basic principles guide smart city initiatives: "citizen (user) centrality," "vision and challenge focus," and "emphasis on inter-disciplinary and inter-city collaboration." These are defined by five basic principles: "ensuring transparency and interoperability," "ensuring fairness and inclusiveness," "ensuring privacy," "ensuring security and resilience," and "ensuring sustainability in terms of operation and funding." These principles guide the development of

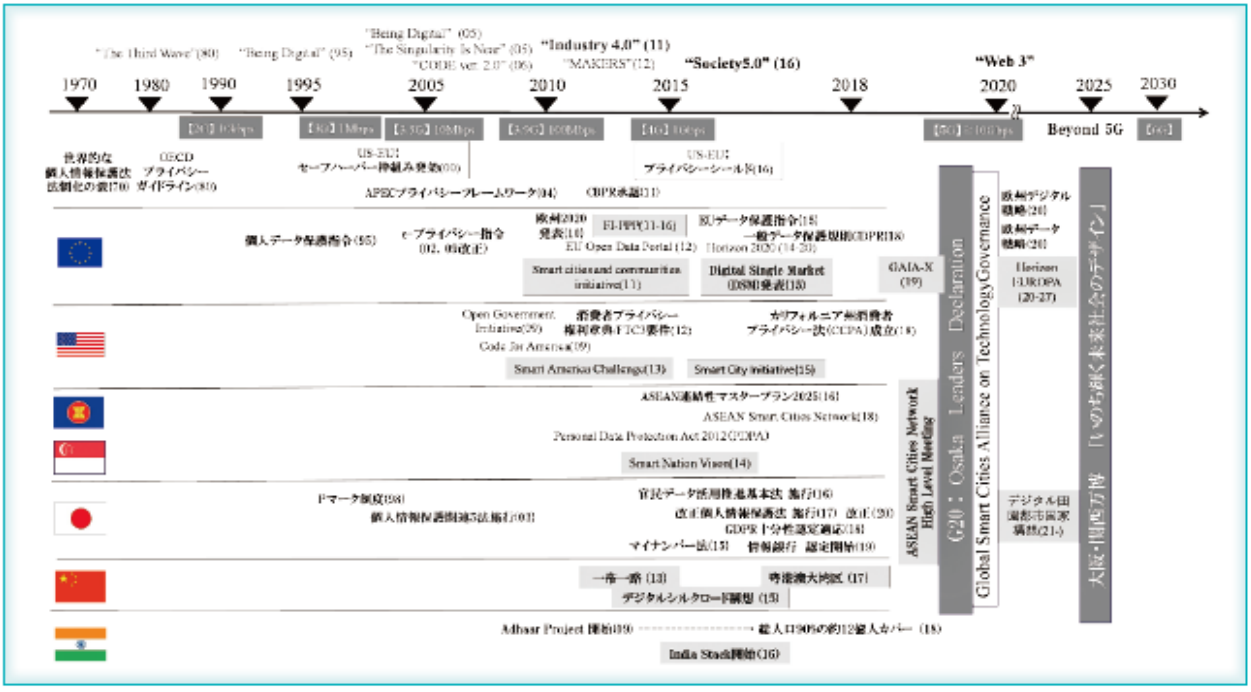

Figure 1. The trends in global data policies and smart city policies

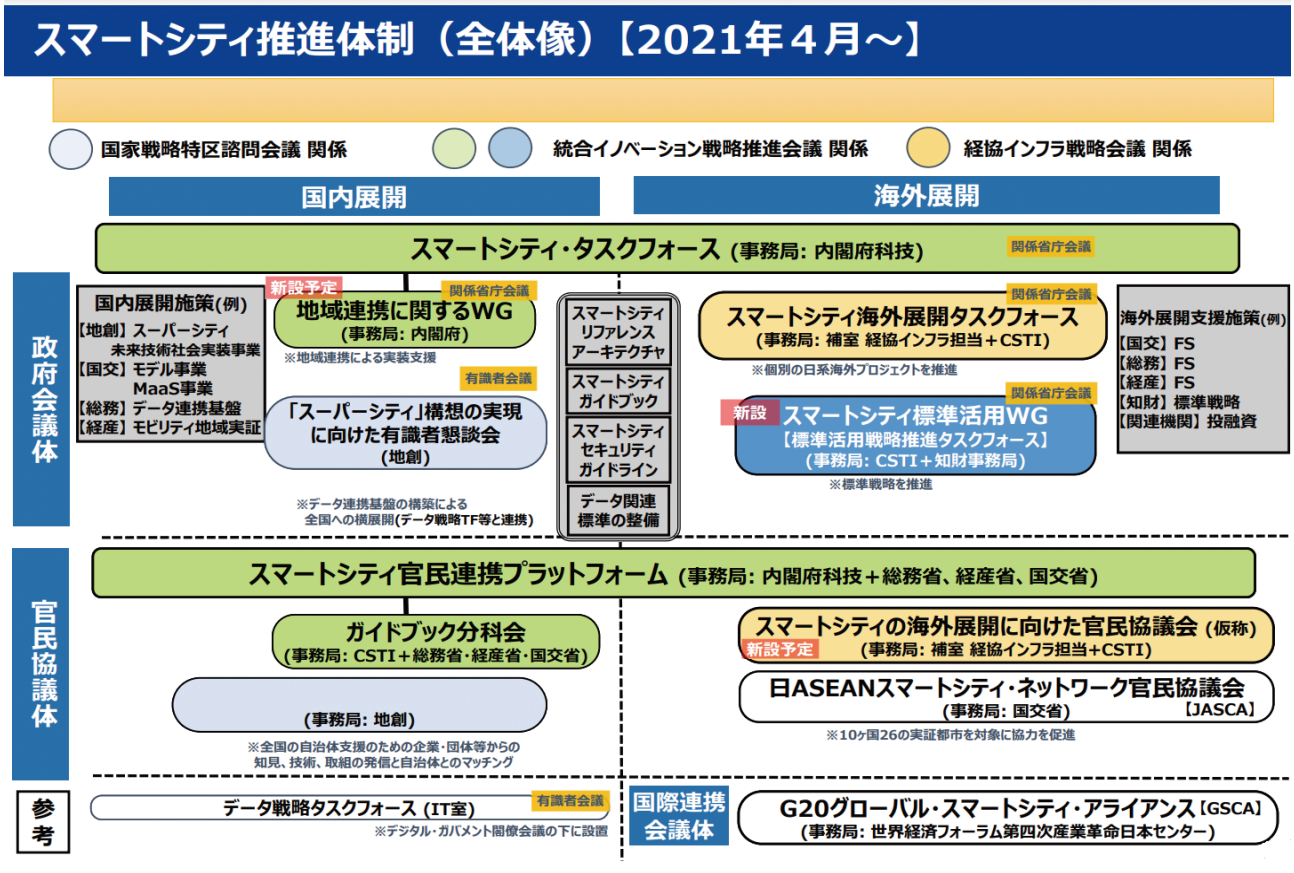

Figure 2. Japan's smart city promotion system

various policies in this field.

2. The approach to smart cities

As for the specific approach to smart cities, the author has been involved in its development, and the "Smart City Guidebook (First Edition)" published by the Japanese government on April 9, 2021, serves as a reference [1]. This guidebook compiles the significance, necessity, implementation effects, and approaches to smart cities, taking into account examples from regions that have already worked on smart cities. It provides an overall perspective on the realization of smart cities (**Figure 3**) to support local public entities and public-private collaboration councils engaged in smart city initiatives.

One particularly notable and challenging aspect is the "introduction of an urban operating system (data integration infrastructure)." An urban operating system (OS) is a data integration infrastructure based on unified rules, providing various new services such as logistics, healthcare, welfare, and disaster prevention. To promote citizen-centered smart cities, it is necessary to design services tailored to individual needs, which requires cross-sector data utilization. Nonetheless, it is crucial to emphasize that it is not merely about a data approach but rather designing smart city services and applications based on vision and challenges, with consideration for data utilization and urban OS design. In addition, handling data necessitates a responsibility for explaining personal information and privacy protection to citizens. The five basic principles of smart cities mentioned earlier hold significance in this context.

In this way, smart cities encompass a wide range of aspects, including vision design, collaboration with the public, governance, data management, and more. Taking an overarching view and finding the optimal solutions tailored to each region is crucial. The presence of architects and similar roles discussed in the next chapter becomes important in driving smart cities forward.

3. The importance of architects and data strategy in smart cities

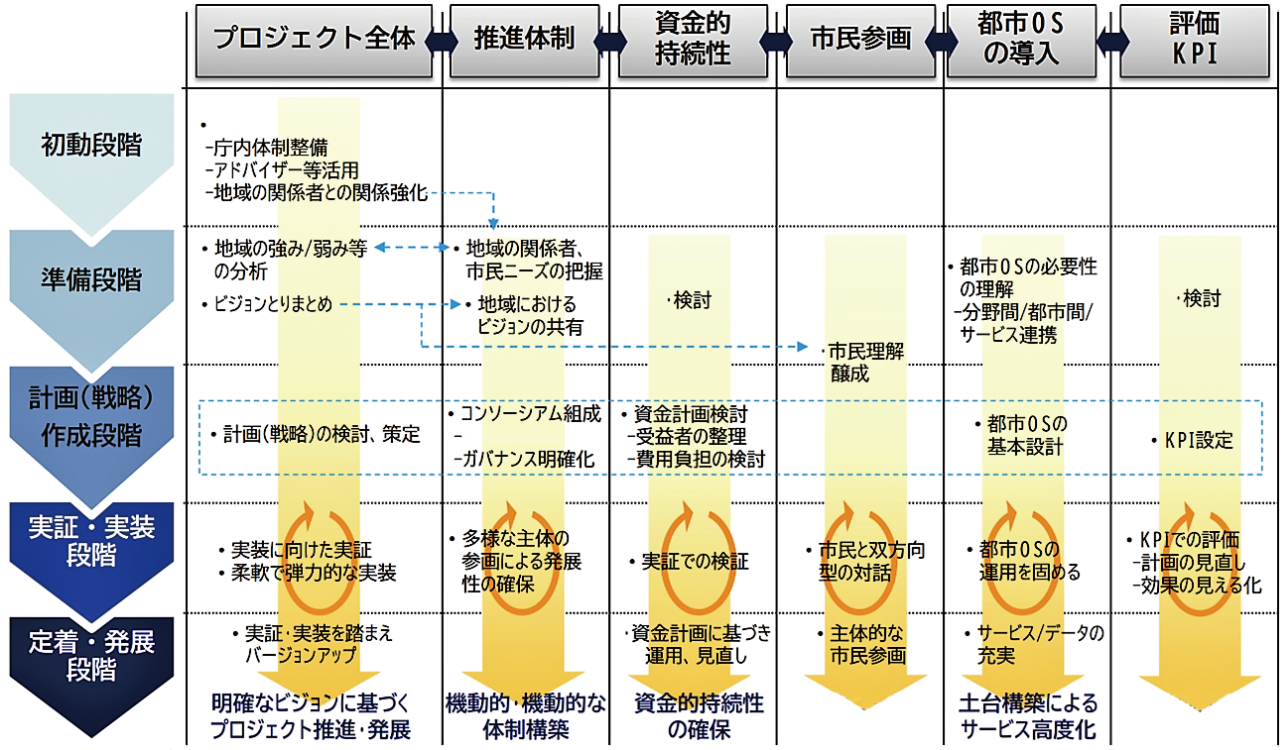

Figure 3. An overview of the overall picture for achieving smart cities

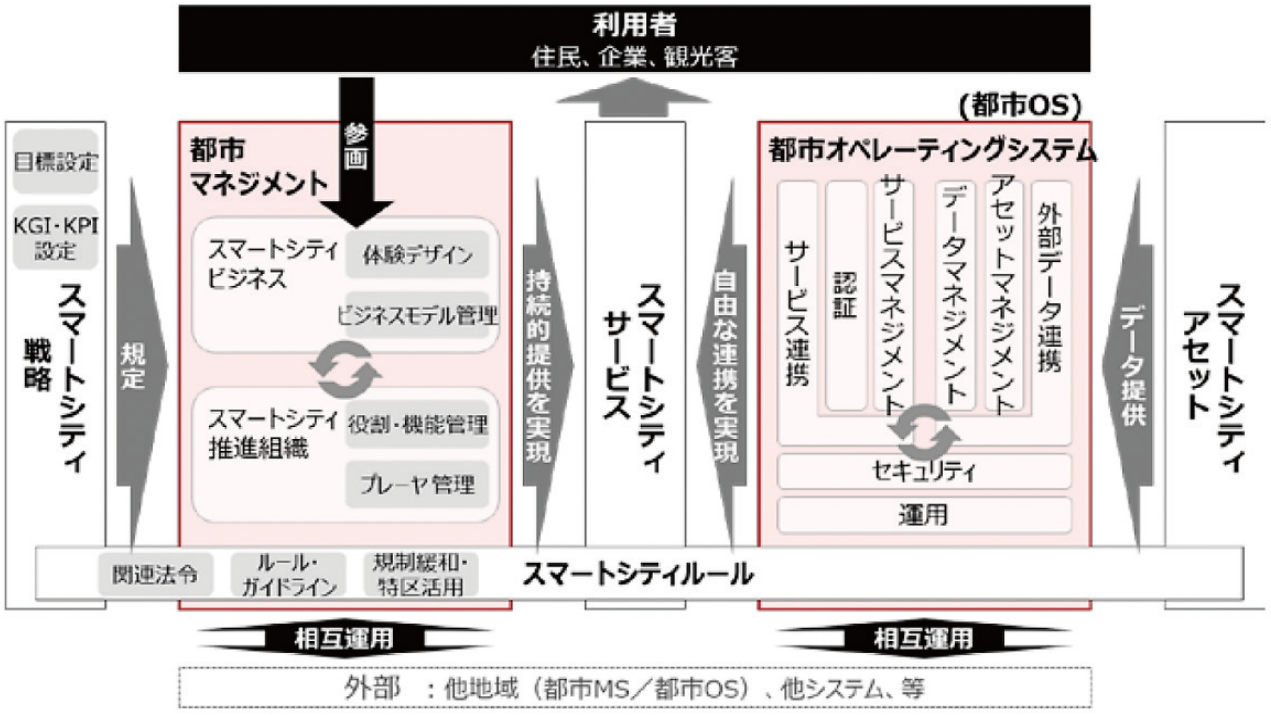

Figure 4. The overall picture of smart city reference architecture [2]

An architect is a professional who performs architecture design, and they exist in various fields such as IT architecture and business architecture. However, the role of architects in smart cities is to oversee the design of the entire social system. As shown in the overall picture of the Smart City Reference Architecture (**Figure 4**), architects set goals for the region while overseeing the entire system. They involve citizens in social validation and aim for social implementation, acting as a command center. In particular, architects must promote the development of smart city services and the utilization of data while considering both urban management and data management within the urban operating system.

To cultivate individuals capable of overseeing such an overall architecture, the Information-technology Promotion Agency – Digital Architecture & Design Center (IPA-DADC) defined the direction of architecture to achieve Society 5.0, as shown in **Figure 5**, in the "Interim Report on Architect Human Resource Development and Cultivation" published in July 2021, and has been working on architect development.

As mentioned in Section 2, various services need to be realized in smart city initiatives, requiring data integration and data utilization across different domains. Architects must not only consider the smart city reference architecture but also pay attention to the data strategy architecture currently being discussed at the Digital Agency (**Figure 6**). Nevertheless, there is a shortage of digital talents in Japan to execute data strategies, and the government has set a goal to train 2.3 million digital professionals, including "business architects," "data scientists," "engineers and operators," "cybersecurity specialists," and "user interface (UI) / user experience (UX) designers," within five years.

4. Challenges in advancing smart cities

Currently, various regions in Japan are actively working on smart city policies with both public and private participation, but the concrete social implementation of these policies remains in the demonstration phase, and there are also sustainability challenges. This chapter discusses the challenges in promoting smart cities and three key points that need further consideration.

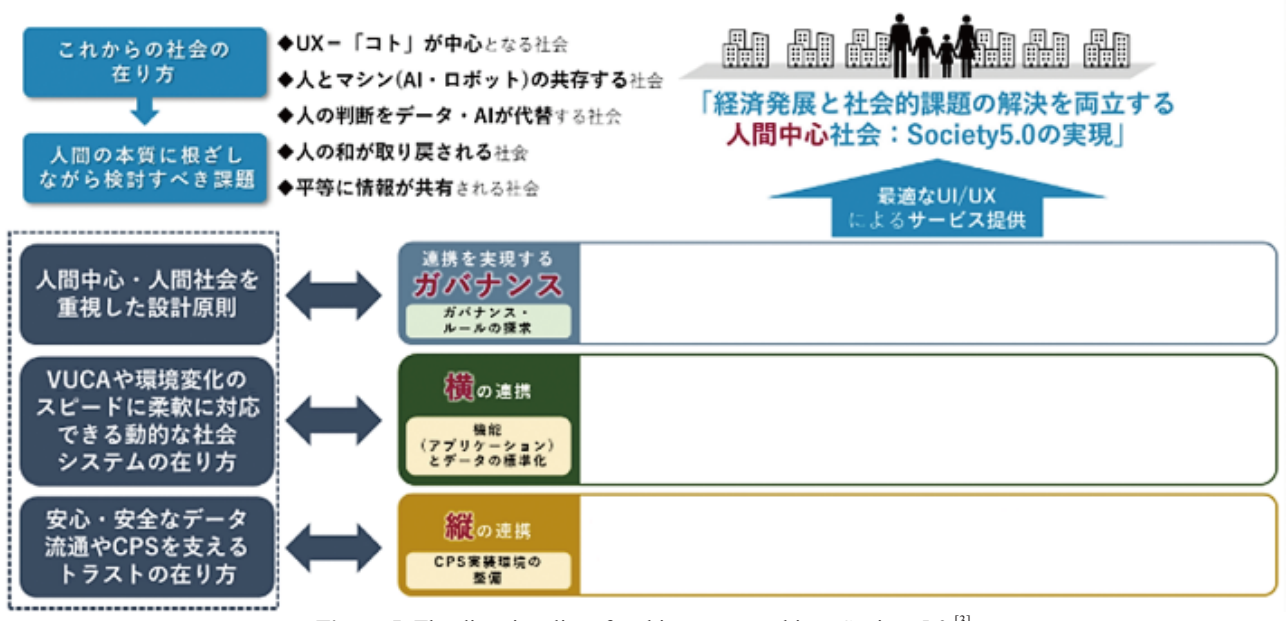

Figure 5. The directionality of architecture to achieve Society 5.0 [3]

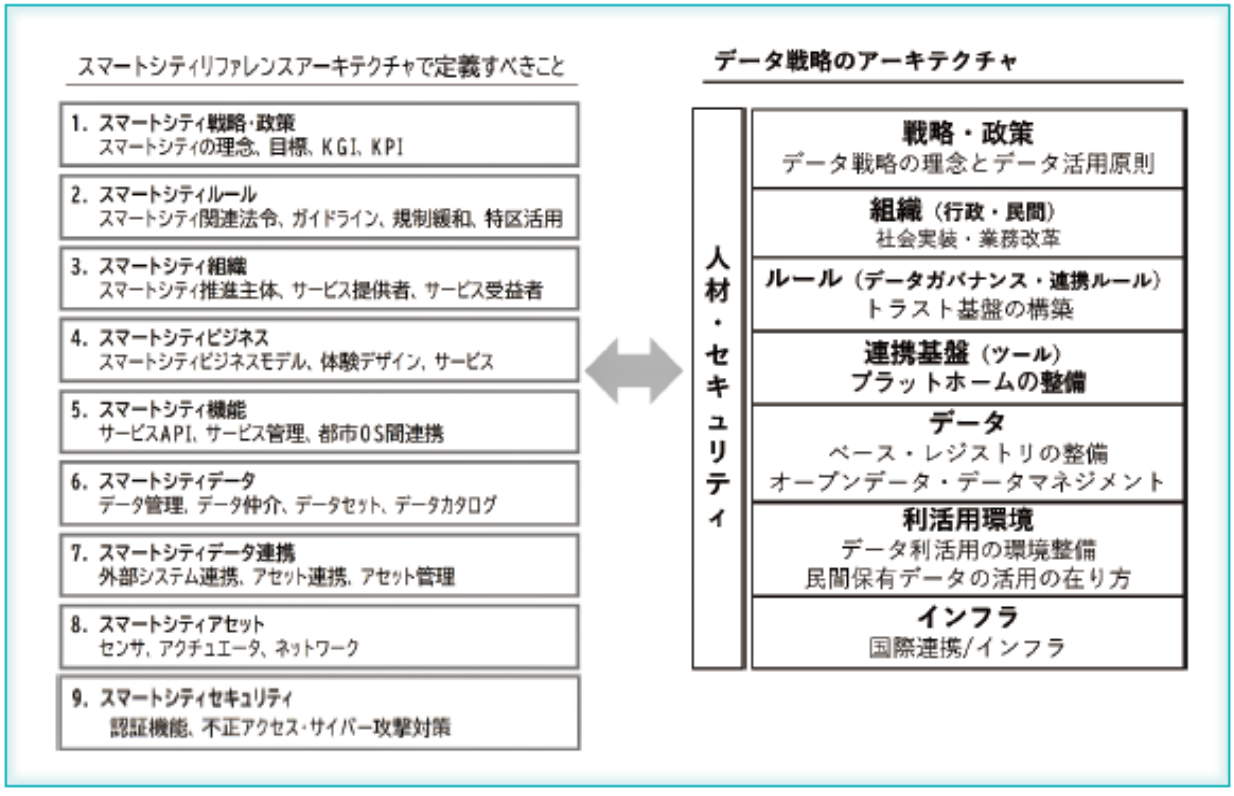

Figure 6. Smart cities and data integration architecture

4.1. The complexity of governance and management

The first challenge is the complexity of governance and management required for the promotion of smart cities. **Figure 7** illustrates the relationship between conventional urban policies and the urban policies required for smart city promotion. In urban policies based on the promotion of smart cities, it is essential to consider both physical spaces, which have traditionally been the focus of urban policies and planning, and cyberspaces through information and communication networks and data integration infrastructure like the urban OS. For example, conventional urban planning involves zoning physical space based on societal needs, establishing area management systems, and developing cities accordingly.

However, in smart cities, there is a need to move beyond traditional physical zoning and focus on creating cities that respond to the needs of residents and visitors, centering around dynamic real-time data flowing through infrastructure elements like IoT devices and sensors. This agile type of urban development, adapted to the needs of the local community, is made possible through Evidence-Based Policy Making (EBPM), which involves policymaking based on evidence. Furthermore, handling data in smart cities also raises concerns related to personal data protection, privacy issues, cybersecurity, and ethical, legal, and social issues (ELSI) associated with science and technology.

To advance smart cities, it is crucial to design an overall architecture from a comprehensive perspective and then conduct urban management. This requires careful planning of the organization responsible for governance and management, given the complex landscape outlined above.

Another point to consider is the speed of technological transition. Urban planning typically spans 20 to 50 years. During this time, new technological innovations can occur rapidly. In 1995, the commercialization of the Internet advanced, followed by the expansion of social networking services (SNS) in 2005, mobile technology in 2010, and the development of AI/IoT and cloud technologies in 2015, leading to increased autonomy. From 2020 onwards, DX is being promoted in various fields, and data communication speeds have been increasing approximately every five years, accompanied by technological advancements.

By 2025, the arrival of beyond 5G (6G: 6th generation mobile communications) and the utilization of small satellites could lead to the control of services that constitute a smart city, such as autonomous delivery robots from space, ushering in an era of managing cities. The Ministry of Internal Affairs and Communications has been discussing the potential impact of solar flares and other solar activities on societal infrastructure such as aviation radio, power grids, communication, broadcasting, and positioning systems, emphasizing the need for advanced space weather forecasting. In the future, while promoting smart cities, it will be important to consider technological trends like these and examine cross-sector technology governance.

Discussions related to governance have been ongoing since 2019, with the establishment of the “New Governance Model Study Group in 5.0” under the Ministry of Economy, Trade, and Industry. This led to the publication of reports like “Governance Innovation: Re-designing Laws and Architecture for Achieving Society 5.0” in July 2020 and “Governance Innovation Ver. 2: Towards the Design and Implementation of Agile Governance” in July 2021. These reports highlight the necessity of new governance models that can both promote innovation and realize societal value in the rapidly changing landscape driven by digital technologies such as big data, IoT, and AI.

4.2. Misconceptions about data integration infrastructure and urban Oss

The second challenge lies in the misunderstanding surrounding data integration infrastructures and urban Oss in smart cities. Data integration infrastructure and urban OS are not fixed systems; instead, the key

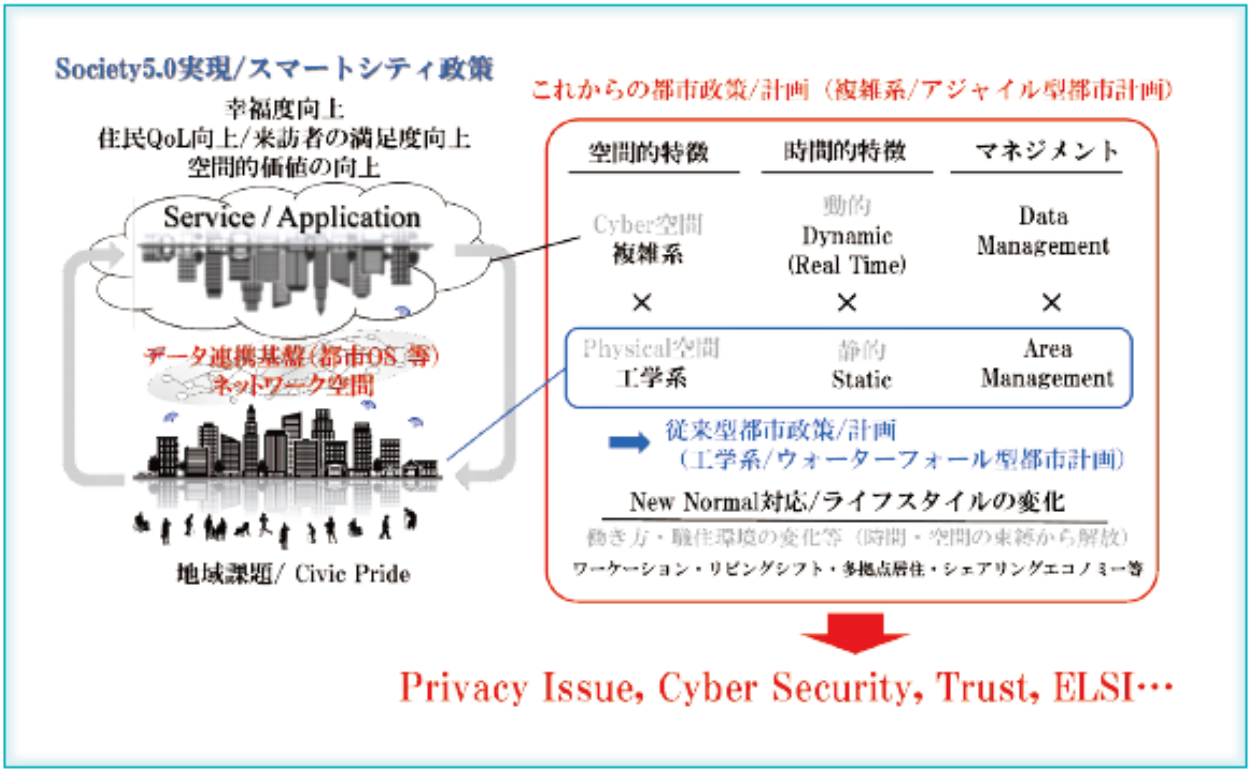

Figure 7. The complexities of smart city management

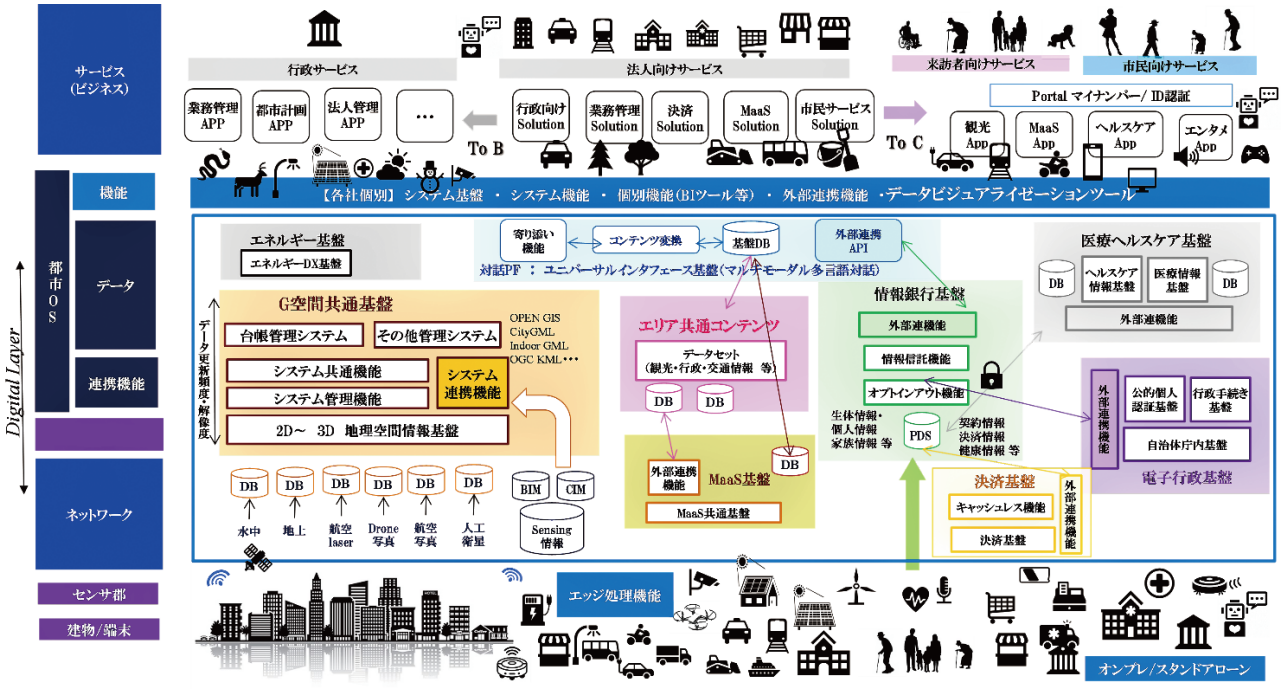

Figure 8. An overview of smart city data integration

is to ensure "interoperability." They can take various forms depending on their intended use. For instance, the European project "GAIA-X," officially launched in June 2020 with leadership from Germany and France, published the "GAIA-X: Technical Architecture." This document outlines the importance of achieving interoperability by integrating various cloud services from companies within and outside of Europe into a single system. It establishes a secure and trustworthy standard authentication mechanism, making it easy to facilitate cross-industry data exchange. In other words, data integration infrastructure and urban OS are flexible concepts designed to ensure that different systems and services can work together seamlessly. The emphasis is on enabling interoperability, not on a specific fixed infrastructure.

For example, Future Internet WARE (FIWARE), a data management platform focused on cross-domain data flow in the IoT era, was developed as the core platform under the European Union (EU)'s 7th Framework Programme (FP7) ICT project, known as the Future Internet Public-Private Partnership (FI-PPP), starting in 2011 with a five-year plan. Various modules of FIWARE are standardized using the Application Programming Interface (API) of the Next Generation Service Interface (NGSI) standardized by the Open Mobile Alliance (OMA), through which data is exchanged. Thus, APIs play an important role in defining data integration to realize services. In the healthcare domain, the Health Level 7 Fast Healthcare Interoperability Resources (HL7 FHIR) standard API has been established for exchanging healthcare information.

When considering smart cities with a focus on urban OS, data integration infrastructure, and IoT devices, there is a possibility of misalignment between the desired services and the means of achieving them. As shown in **Figure 8**, urban OS and data integration infrastructure are means to achieve services. It is crucial to determine through APIs what data needs to be integrated to realize the desired services. However, it is also essential to avoid the misconception of confusing the purpose and means in smart city planning, as cases of such misunderstandings have been observed.

4.3. The establishment of a financing scheme to ensure sustainability

The third challenge is the immaturity in building the financing scheme necessary to ensure the sustainability of smart cities. The data integration infrastructure and urban OS required to operate the aforementioned smart city-related services naturally incur initial investment costs and ongoing maintenance and operation costs. Additionally, there are various costs associated with the introduction of cutting-edge technologies. It is still under examination as to who should bear these costs and how to construct a sustainable societal model. Currently, reliance on subsidies is unavoidable, and it can be said that there are no successful examples yet.

Solving these challenges requires the realization of EBPM using data and high-resolution discussions on profitability based on such data. Furthermore, in addition to existing public-private finance schemes such as private finance initiatives (PFI) and business improvement districts (BID), it is expected that the construction of a new smart city business ecosystem will be promoted by combining various finance schemes such as social impact bond (SIB), which is a pay-for-success (PFS) contract method representing results-based private sector outsourcing, Green Bonds, which are bonds specialized in raising funds for new or existing projects or activities that have a positive impact on the environment, and Social Bonds, which are bonds specialized in raising funds for businesses and social activities addressing societal issues, i.e., sustainability-themed bonds.

What is crucial here is to enhance the resolution from the early stages of smart city promotion regarding what services are provided, what data is required, who directly or indirectly benefits, and what positive impact it has on society. In particular, PFS projects through SIB

involve raising funds for the project from fund providers such as financial institutions and carrying out repayment and other activities based on the improvement status of outcome indicators and are therefore necessary for the sustainability of smart cities.

5. Conclusion

The Japanese government has set forth the "Digital Rural City State Concept" as a trump card for revitalizing rural areas and aims to create a new wave of transformation by advancing digital implementation in these regions, thereby narrowing the gap between rural and urban areas. In the future, it is expected that the promotion of smart cities will continue to advance in various regions. The realization of smart cities depends on the active involvement of citizens. From the fundamental principle of citizen-centered smart cities, it is important to achieve a transformation from a society where people's lifestyles are determined or limited by urban space to a society where cities adapt to people's lifestyles.

Japan's industrial sector should always return to the fundamental principle of putting "citizens as the subject" and promote DX while designing and implementing future societies filled with hope in each region, in collaboration with citizens.

Disclosure statement

The author declares no conflict of interest.

References

[1] Secretariat for Science, Technology and Innovation, Cabinet Office, Government of Japan. Smart City Guidebook (1st Edition), 2021, Tokyo.

[2] Director-General for Science, Technology and Innovation, Cabinet Office, Government of Japan. Smart City Reference Architecture White Paper, 2020, Tokyo.

[3] Information-technology Promotion Agency, Digital Architecture Design Center (IPA-DADC). Interim Report on the Development and Training of Architects, 2021, Tokyo.