Actions of Hitachi-UTokyo Laboratory toward Realizing Next-generation Smart Cities

Hitachi-UTokyo Laboratory was established with the goal of realizing Society 5.0, work that has included the Habitat Innovation project aimed at helping create data-driven people-centric smart cities. This article describes this project by presenting: (1) a framework for policies to create a human-centered society that combines economic growth with the resolution of societal challenges, (2) collaborative creation between the arts and sciences that includes study of QoL assessment and public acceptance of data use, and (3) an overview of the current progress and future prospects of the Matsuyama Smart City project that serves as an example of how these ideas can be put into practice.

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1. Introduction

Hitachi-UTokyo Laboratory was established at the University of Tokyo in June 2016 with the aim of realizing the Society 5.0 future vision presented in Japan's 5th Science and Technology Basic Plan[1]. The Comprehensive Strategy on Science, Technology and Innovation for 2017 refers to Society 5.0 as follows: "The vision of future society to which the 5th Basic Plan proposes that we should aspire will be a human-centered society that, through the high degree of merging between cyberspace and physical space, will be able to balance economic advancement with the resolution of social problems by providing goods and services that granularly address manifold latent needs regardless of region, age, gender, or language to ensure that all citizens can lead high-quality lives full of comfort and vitality." Hitachi-UTokyo Laboratory is working on two projects that aim to help realize this vision, entitled "Energy Systems" and "Habitat Innovation" (see **Figure 1**). The Energy Systems project is producing and promulgating recommendations based on considering the total energy system needs of Society 5.0[2]. The Habitat Innovation project, meanwhile, seeks to use habitat reform as a starting point for creating people-centric smart cities based on the ideas of Society 5.0. This article describes the concepts and activities of Habitat Innovation.

2. What Habitat Innovation Hopes to Achieve

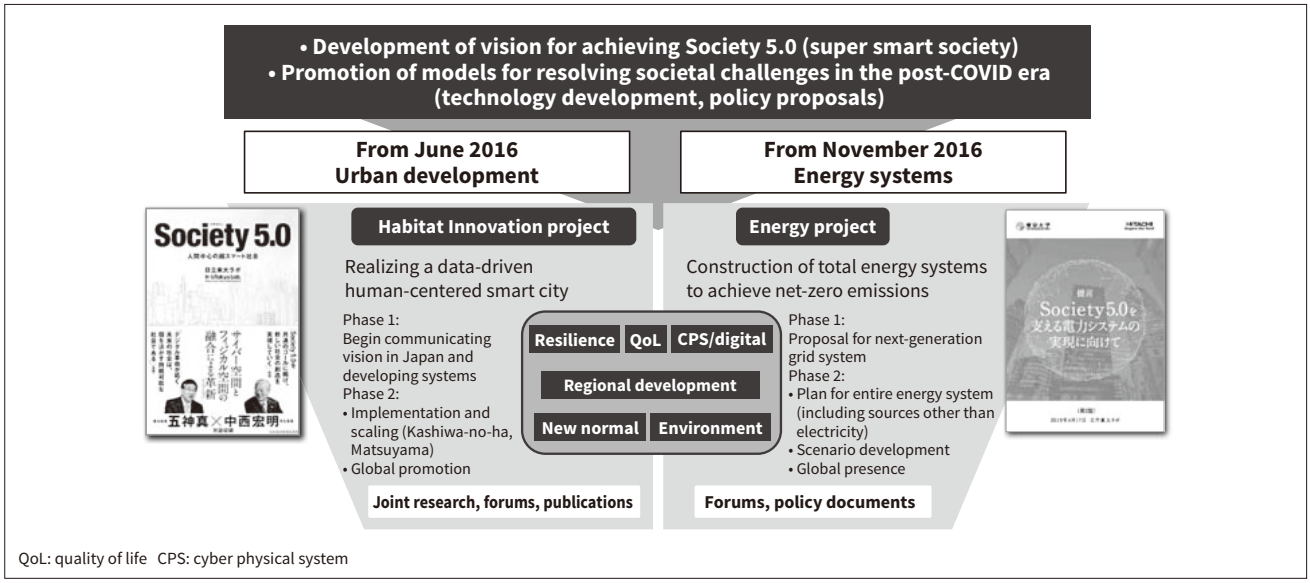
2. 1 Habitat Innovation Framework for Resolving Societal Challenges

Hitachi-UTokyo Laboratory has proposed the key performance indicator (KPI) link concept described below as a means of achieving a human-centered society that combines economic growth with the resolution of societal challenges[3].

One example of a societal challenge that exists worldwide is that of reducing per-capita emissions of carbon dioxide (CO_2). Depending on how it is interpreted, however, the CO_2/population indicator used by the United Nations among others tends to suggest that people should make the sacrifice of becoming less active (see the top half

Figure 1 — Work by Hitachi-UTokyo Laboratory

Hitachi-UTokyo Laboratory is doing work in the fields of urban development and energy systems with the aim of helping achieve Society 5.0.



QoL: quality of life CPS: cyber physical system

of **Figure 2**). Scenes such as government offices in Japan sweating out the hottest days of summer, and setting their air conditioning to 29°C, are not unusual. If the targeted indicators are seen as something to be achieved by suppressing people's wants and actions, as in this example of energy saving based on self-denial, the resolution of societal challenges and economic development will inevitably come to be seen as conflicting objectives such that achieving both at once is very difficult.

In response, Hitachi-UTokyo Laboratory has proposed the "KPI link" concept that accounts for the achievement of both goals by transforming indicators like this one that are expressed as a fraction into a formula made up of multiple factors instead, which is done by multiplying the numerator and denominator of the fraction indicator by the same parameters (energy use and activity level). In other words, by using factorization to break the indicator up into three terms, Hitachi-UTokyo Laboratory attempts to express indicators in a way that more clearly represents the Society 5.0 philosophy of combining the resolution of societal challenges with lifting per capita economic activity (see the lower half of **Figure 2**).

When using per-capita CO_2 emissions as an indicator for the societal challenges posed by global warming, for example, reducing this indicator involves using the KPI link formula to break the indicator down into three separate terms so as to also account for methods of combining economic growth with the resolution of this societal challenge and the role of research and development, such that each of these three terms serve as indicators to be targeted.

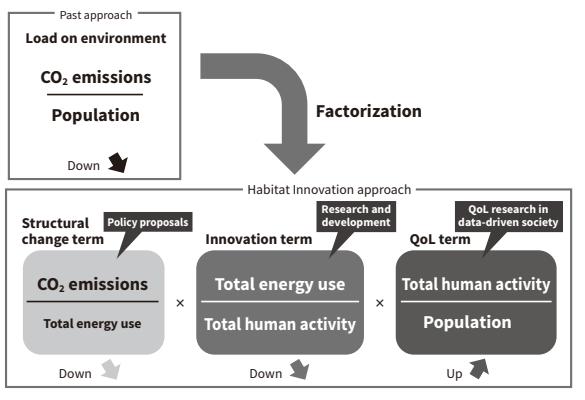
The left-hand term in the lower half of **Figure 2** represents CO_2 emissions per unit of energy use. As reducing this indicator requires changes such as the use of renewable energy, it corresponds to structural change that aims to achieve this goal through policy measures and the like.

The second term represents energy use per unit of human activity. As reducing this indicator requires improvements in the performance of urban infrastructure (including homes and other buildings) achieved through technological development, it can be thought of as corresponding to innovations that seek to achieve this goal through things like the development of technology.

The third term represents the extent to which people are able to live active lives in a comfortable environment, expressing the richness of people's lives as well as contributing to economic development. This term can be thought of as corresponding to quality of life (QoL).

Figure 2 — KPI Link Approach for Facilitating Resolution of Societal Challenges

By multiplying both the numerator and denominator of a societal KPI (in this case, per-capita CO_2 emissions) by the same parameters (energy use and activity level), the indicator can be expressed in factorized form as the product of three separate terms. The terms in this case explicitly express the philosophy of Society 5.0, corresponding to structural change, technological innovation, and QoL respectively.



KPI: key performance indicator

KPI link is not only able to more clearly express the roles that policy and technological development will need to play if the overcoming of challenges is to be combined with economic development relative to societal challenge indicators from various different sectors, it also provides an intelligible way to share what it is Hitachi-UTokyo Laboratory is seeking to achieve through research and development. In other words, the KPI link idea that arose out of breaking up indicators into multiple factors can be applied to a wide variety of other indicators that relate to the resolution of societal challenges and Hitachi-UTokyo Laboratory believes that it provides a useful way to clarify what is meant by the Society 5.0 goal of combining economic development with the resolution of societal challenges while also enhancing QoL, and also the roles of the research and development and policy work aimed at achieving this.

2. 2
Habitat Innovation Project

The Habitat Innovation project has undertaken the following work toward the creation of human-centered smart cities as a guideline to the framework described above.
(1) The generation and accumulation of urban data that serves as a basis for creating new value, and the establishment of information handling infrastructure for turning this data into knowledge and value.
(2) Serving as a hub for utilizing this urban data and information handling infrastructure to create value, accelerate coordination and collaborative creation (co-creation) between residents and other stakeholders and present the ideas to the global public.

Through these activities, the project hopes to help create data-driven smart cities that feature a high-level merging of cyberspace and physical space. This involves establishing a data integration platform that delivers effective urban management in ways that can adapt quickly to the issues on the ground through data utilization techniques with a fast cycle time that encompass the acquisition of data and its immediate transformation into information and high-level decision-making by experts (turning information into knowledge). Moreover, utilizing technologies such as artificial intelligence (AI) and the Internet of Things (IoT) for the real-time data processing of data acquisition and its transformation into information and knowledge delivers improvements in QoL, making it possible to apply this directly to people's activities and resulting in a short cycle time (autonomous improvement cycle) in which people can make their own choices about what they want to do (see **Figure 3**).

Meanwhile, knowledge about public acceptance, which is to say about how to get the public (the users of the technologies that put data to work) to accept this technology, and the accumulation of this knowledge, are vital if the technical, business, government, and other organizations involved in Society 5.0 are to establish the grounding for data use and the practices to follow. If the framework for data use is designed without consideration for public acceptance, the data-driven society will no longer be synonymous with a human-centered society. What this means is that, in terms of how policies are determined, there is a need to explore areas where engineering overlaps with the humanities such as social psychology, social ethics, and philosophy. Accordingly, the project includes co-creation between the arts and sciences on the study of how to evaluate smart cities in the context of a human-centered society, QoL assessment, and public acceptance of data use[4].

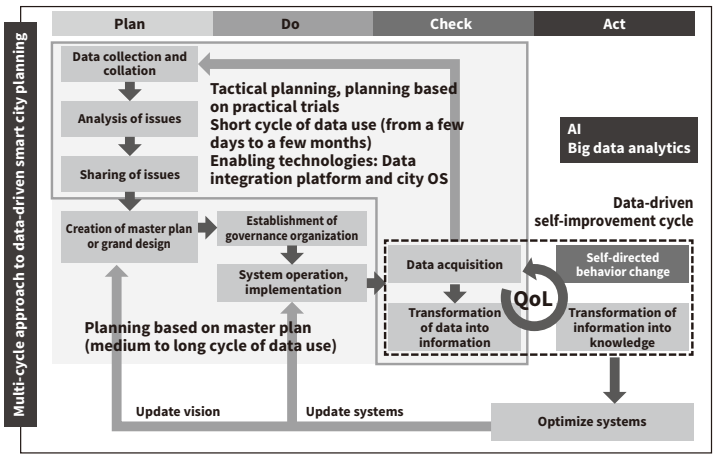
Along with defining what is meant by next-generation human-centered smart cities, work has also started on putting these ideas into practice in the field. The following section describes the work being done in one such instance of this at Matsuyama City in Ehime Prefecture.

3. Matsuyama City Project

One of the places where Hitachi-UTokyo Laboratory is putting Habitat Innovation into practice is Matsuyama City in Ehime Prefecture where a demonstration project has been underway since 2017[5]. The work is being undertaken in tandem with the city's own work on implementing its Matsuyama City's Initiative Plan for a Walkable and Livable Town[6] and is also linked to the Ministry of Land, Infrastructure, Transport and Tourism's smart city model project selected for FY2019. This section presents an overview of the Matsuyama smart city project and describes future plans that take account of COVID-19 and natural disaster response.

3. 1
Overview of Matsuyama Smart City Project

Progress is being made on the on-site application and evaluation of a data-driven approach to urban planning promoted by Hitachi-UTokyo Laboratory for the designs of the plazas outside the Matsuyama City Station of the Iyotetsu railway company and Japan Railways' Matsuyama Station and the pedestrian spaces that link these transportation hubs. Along with the use of four specific technologies to ensure that urban spaces are fully utilized, namely (1) City Probe (the use of sensing to collect data on the flow of people and traffic in the city), (2) City Data-Spa (an urban data platform that is closely integrated with the community), (3) City Sim (simulations for evaluating the benefits of urban development measures), and (4) City Scope (use of Cyber-Proof-of-Concept for Cities, a data visualization tool), it also includes work on establishing new urban services such as City Ride (a next-generation mobility service).



AI: artificial intelligence IoT: Internet of Things OS: operating system

Figure 3 — Process of Data-driven Smart City Planning

Standard practice for urban planning in the past has been based on a long cycle of data use of around five to 10 years through a process of surveying, data collection and analysis, clarification of the issues, and the steps from formulation through implementation, evaluation, and updating of the city plan. Urban planning initiatives undertaken at various locations over recent years, however, such as practical trials, demonstration projects, and tactical urbanism, have been limited small-scale activities running over comparatively short timeframes of a few days to a few months. In contrast to the five- to 10-year cycle for revising plans in the past, these initiatives can be thought of as representing a short cycle of data use. Furthermore, utilizing technologies such as AI and the IoT for the real-time acquisition of data and its transformation into information and knowledge makes it possible to apply this directly to people's activities in ways that are independent of the past cycle of data use and planning. In other words, having the required information distributed (or acquired) at the optimal timing, with real-time operation being the default, improves QoL by giving rise to an autonomous improvement cycle in which people can make their own choices about what they want to do.

The aim of all this is to create a "walkable and livable town full of happy faces" (see **Figure 4**).

Included in this work is use of the following measures to put in place the City Data-Spa urban data platform that is being investigated by the Smart Digital Solution Business Development Division of Hitachi, Ltd.

(1) The collection of data acquired by sensing systems and various associated data.

(2) The provision of functions for collating the collected data, transforming it into useful information, and linking it into other systems.

(3) Turning it into an information platform that will facilitate data visualization and benefit assessment using various information with the potential to deliver new benefits or insights.

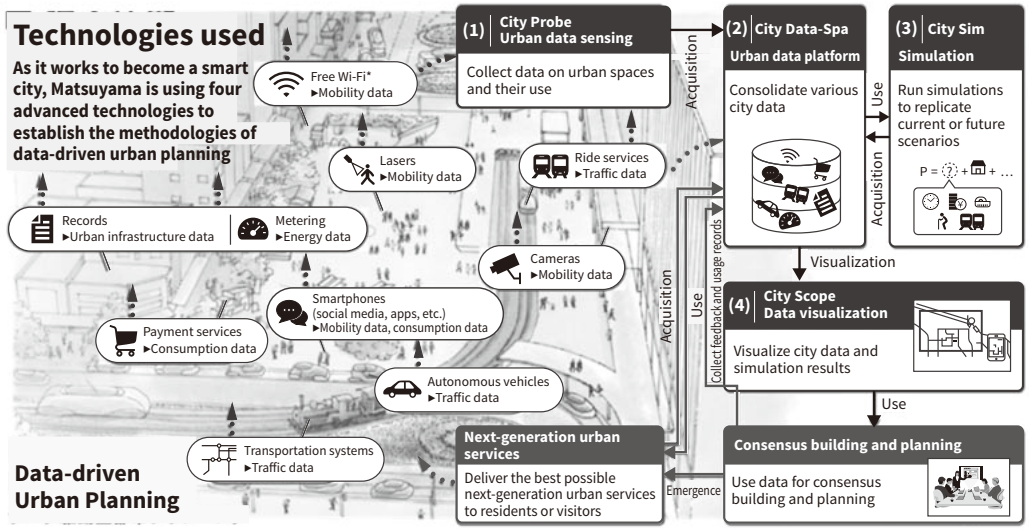
While the urban data platform will initially be used for city planning, it is being designed to link more widely and deal with a broader range of information and applications in the future, allowing for an expansion in its scope with a view to its ultimately being used by the private sector. Application of the urban data platform to Matsuyama will be undertaken through a design-oriented process that involves establishing a trial design, building a prototype, reviewing its specifications and functions, including a user interface that users find useful and easy to use, and making ongoing functional upgrades and revisions (see **Figure 5**).

3. 2
Future Prospects for Data-driven Planning

Adopting planning practices that utilize digital technologies as described above allows for the creation of optimal urban

Figure 4 — Overview of How Matsuyama Intends to Go about Data-driven Urban Planning

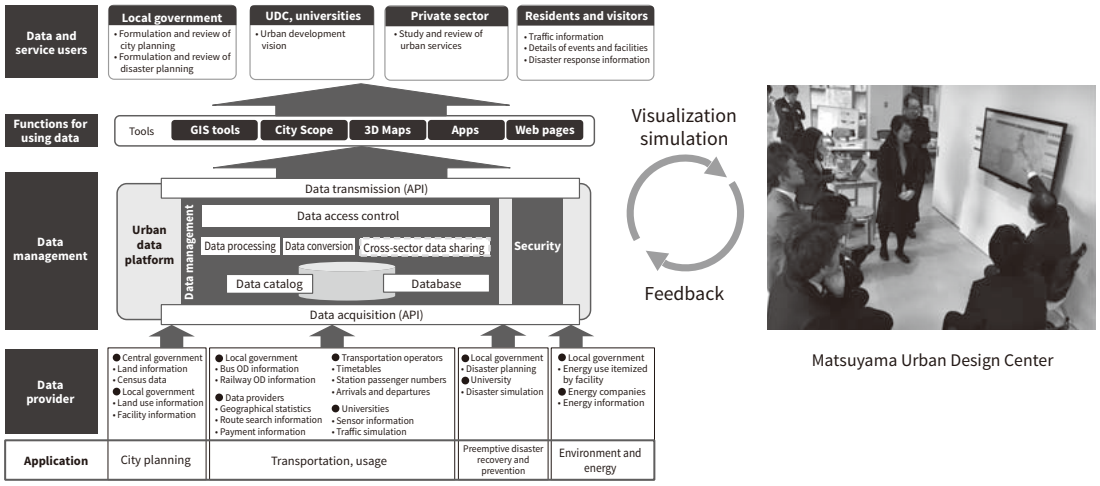
The city will create next-generation urban services by collecting, consolidating, and presenting a variety of urban data for use in planning and for consensus building with residents.



* Wi-Fi is a registered trademark of the Wi-Fi Alliance.

Figure 5 — Overview of City Data-Spa Urban Data Platform

Transform data for different fields related to urban development into forms that facilitate visualization and simulation, and make it available to the people involved in urban development and the providers of next-generation urban services.



Matsuyama Urban Design Center

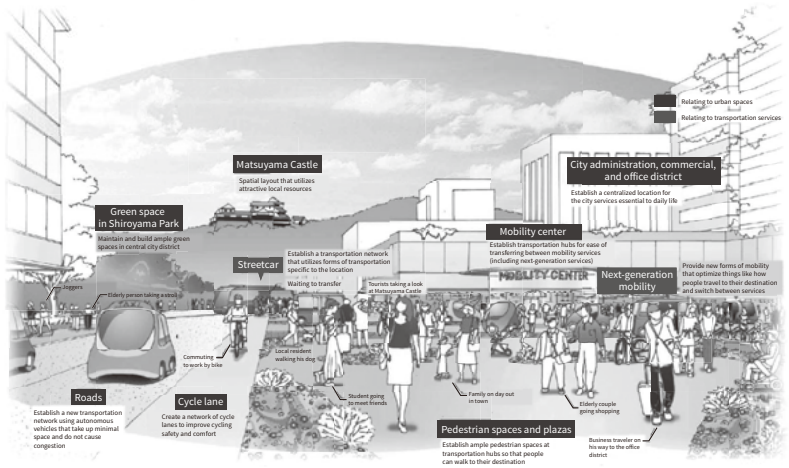
UDC: Urban Design Center GIS: geographic information system 3D: three-dimensional API: application programming interface OD: origin destination

spaces and achieving the synergistic benefits of next-generation city services. Moreover, along with the QoL gains for residents, which include health benefits and fostering a joy of living by creating a place where people can enjoy a pedestrian lifestyle, it is also seen as something that will facilitate the implementation of economic revitalization measures through a closed-cycle economy with low carbon emissions, being more attractive as a tourist destination, and encouragement for greater interaction (see **Figure 6**).

Putting data-driven planning into action is also an urgent matter in order to anticipate and quickly respond to events such as the COVID-19 pandemic and severe rainstorms of recent times or other natural disasters such as the Nankai Trough megaquake that is predicted to strike in the not-too-distant future. Along with its use for urban development during normal times, as described above, work is also proceeding in parallel on the use of data-driven planning at other times. This includes the application of techniques for simulating the movement of people to look at how they would behave in an evacuation prompted by a tsunami; the use of people flow measurement techniques to help people avoid Three-Cs: closed spaces, crowded places, and close contact settings, a useful application given the current COVID-19 pandemic; and a remote workshop on the use of City Scope in urban development (see **Figure 7**).

4. Conclusions

This article has described the work being done by Hitachi-UTokyo Laboratory on next-generation smart cities. While activities based around putting this work into practice at Matsuyama and Kashiwa-no-ha Smart City are only now getting underway from FY2020, it is likely that COVID-19



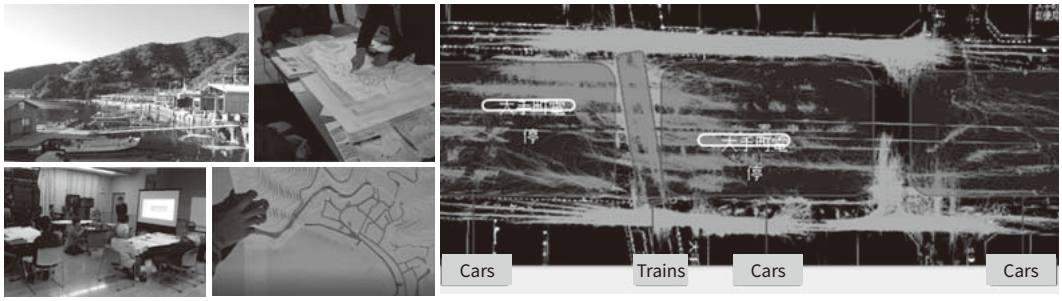
Source: Conceptual drawing from Ministry of Land, Infrastructure, Transport and Tourism's Smart City Model Project

Figure 6 — Smart City Goals of Matsuyama City

The aim is to combine greater QoL for residents and economic revitalization through tourism by creating a "walkable and livable town full of happy faces" while also working to reduce carbon emissions and better prepare for disasters.

Figure 7 — Pre-emptive Disaster Recovery Work at Ainan in Ehime Prefecture (left) and Use of Laser Sensors to Track Arriving and Departing Passengers around Matsuyama's Otemachi Station (right)

Use of activity simulation and situation assessment by people flow measurement is being applied to improving emergency evacuation and transfers between different forms of public transportation.



will bring major changes to how smart cities are conceived. As remote practices become more common and the implications of this for urban spaces and lifestyles become clearer, there will be a need to put data to use in resolving the new urban challenges that will likely emerge. People flow data, for example, will likely have a role in encouraging behavioral change to prevent the formation of crowds and maintain social distancing. It is anticipated that use of cyberspace will become more important than ever for helping create inclusive urban societies that protect the vulnerable and the Habitat Innovation project intends to continue working toward making this happen.

Acknowledgements

Professor Eiji Hato of the Graduate School of Engineering, The University of Tokyo provided advice on the Matsuyama Smart City project described in this article. The authors would like to take this opportunity to express their deep thanks for this assistance.

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