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REVIEW ARTICLE
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Exploring Adaptation of Transportation Policy to Revolution Challenges: Evolution of Transportation Services and the Concept of Next-generation Solutions

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Abstract:
This paper explores how transportation policy can respond to the transportation revolution driven by the diversification of business models through technological innovations, such as the Internet of Things (IoT) and Artificial Intelligence (AI), as well as the transformation of transportation equipment into information terminals. First, the evolution of transportation services and the concept of Mobility as a Service (MaaS) are organized to clarify the meaning of next-generation transportation services. Using a historical approach to transportation research and empirical knowledge of transportation coordination theory during the previous transportation revolution (marked by the emergence of automobiles and airplanes), this study examines the policy implications of MaaS through the concept of "interpretation circulation." Finally, it summarizes the current status and challenges in implementing the Japanese version of MaaS and suggests future directions.

Keywords: Next-generation transportation services, Transportation integration, Japanese version of MaaS, Co-creation, Multidimensional perspective, Artificial Intelligence (AI), Internet of Things (IoT).

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1. INTRODUCTION

In recent years, technological advancements on the Internet of Things (IoT) and Artificial Intelligence (AI) have transformed the transportation sector, enabling the growth of Mobility as a Service (MaaS). Car-dispatch applications such as Uber and DiDi Chuxing, as well as shared bicycles and motorized vehicles, have become widely available. The automotive industry has also seen progress through Connected, Automated, Shared, Electric (CASE), and the introduction of Electric Vertical Take-Off and Landing (eVTOL) aircraft, which combine features of helicopters and drones, has further expanded transportation options globally. These innovations have led to significant changes in transportation equipment and services [1-14].

Furthermore, to understand the current Transportation Revolution driven by IoT and AI, this paper examines the coordination of transport theory, drawing on historical discussions following the previous Transportation Revolution [15-17]. These discussions addressed the decline of traditional transportation markets and the rapid growth of private car traffic. Within this context, we explore the implementation of the Japanese version of MaaS and consider the policy approaches needed for its social implementation [18, 19].

This paper begins by organizing the concepts of next-generation transportation services, focusing on the evolution of transportation services, the integration of regional transportation with Mobility as a Service (MaaS), and the typology of MaaS. It then reviews the policy philosophy behind "transportation coordination theory" and subsequent interpretations of what the transportation system should encompass, such as "seamless transportation," "barrier-free transportation," "MaaS" and "regional transportation integration." By clarifying the hermeneutic cycle within these interpretations, the paper discusses the policy implications of next-generation transportation services. Next, it summarizes the status and challenges related to the social implementation of next-generation transportation services in Japan. Finally, it considers the future directions for the Japanese version of MaaS in addressing these challenges.

2. THE MEANING OF NEXT-GENERATION TRANSPORTATION SERVICES

2.1. Evolution of Transportation Services

According to Felson and Spaeth (1978), the sharing economy involves integrating unused goods and various service providers in an economic society to offer goods and services at lower-than-usual prices. It is an economy based on the sharing of goods and services. According to data from the Japan Sharing Economy Association, January 2023, the domestic sharing economy market size is expected to reach 2,615.8 billion yen in 2022 and expand up to 15,116.5 billion yen by 2032 [20].

In the transportation sector, the development of IoT technology has recently facilitated the creation of new transportation services, including better utilization of underused urban cars, parking spaces, and the leisure time of driver's license holders. Additionally, shared bicycles and electric scooters have been introduced to ease travel between points of origin or destination and the nearest public transportation stops. Kickboards and other forms of shared mobility have also been introduced in many places. These shared mobility options have grown to supplement public transportation and are now recognized as personal services that can be used anytime without prior planning [21]. Additionally, by examining the transportation equipment market, which has supported the evolution of transportation services, we note that the automotive industry, which has favored the self-production of transportation services, is currently pursuing the development of CASE with a view to social implementation in smart cities [22, 23]. Moreover, research and development related to eVTOL, which can transport small numbers of passengers in large urban areas, is being conducted in various countries [24].

Thus, the evolution of transportation services through technological innovation of IoT and AI can be read as a digital transformation of services (hereinafter abbreviated as DX in Japan) from two aspects: (1) diversification of business models and (2) transformation of transportation equipment into information terminals. The first is the partial sharing of production factors of transportation services. The second is the "multi-functionalization" of transportation equipment, which includes navigation systems, driver assistance technologies, connectivity with other terminals, entertainment systems such as video viewing and Internet access, and energy efficiency, along with the "enhancement" of information processing for automated driving. The "ground linkage" is characterized by "high performance" in information processing, "customization" to suit the user, real-time data sharing, remote monitoring and management, and vehicle data analysis.

Furthermore, as confirmed by MaaS cases in Japan and abroad, transportation services are moving in the direction of next-generation services from "something you give" to local communities to "something you create together," in other words, "co-creation" [25, 26] with transportation operators, transportation users, and related entities.

Transportation is fundamentally driven by human intent and actions, and its service provision cannot be achieved without the involvement of transportation operators, transportation objects, and relevant local entities [17]. As shown in Fig. (**1**), existing public transportation operators, such as railroads and buses, possess or utilize production factors (1) ~ (5) to achieve transportation (production of transportation services) in the form of an assortment or combination of transportation objects. Conversely, the newly emerged sharing mobility differs from existing public transportation in that it is based on the principle of partial sharing of production factors, such as transportation equipment, corridors (including parking spaces), labor, and information. It is positioned as something between commodity production and the self-production of transportation services [17]. Next-generation transportation services, such as shared mobility and MaaS, represent the realization of mobility through the sharing of information and partial sharing of the production factors (1), (2), and (5) of transportation services. This can be interpreted as the result of the collaborative participation of local entities involved in sharing transportation assets and these production factors.

2.2. Mobility Integration and MaaS

MaaS represents the digital transformation of public transportation through data integration of multimodal services. Interpretations of MaaS can be divided into two categories [8, 10, 27-31].

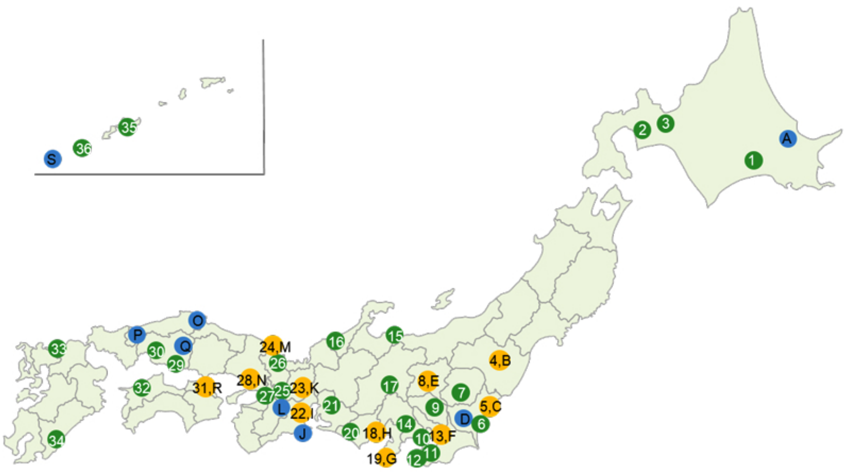
2.2.1. Market-oriented MaaS

Market-oriented MaaS focuses on increasing public transportation use by enhancing user convenience, emphasizing market forces. It aims for seamless movement *via* integrated data, creating value beyond the costs of self-produced transportation services. Tachibana (2023) describes it as a "travel agency for daily transportation" [32].

2.2.2. Problem-solving MaaS

Problem-solving MaaS views MaaS as a tool for addressing regional issues through community development, considering the region as a whole [33, 34]. It enhances transportation functionality by connecting scattered regional services, creating transportation communities that include locals and others engaged with the area [35]. This approach seeks to revitalize regions and improve societal well-being by optimizing the flow of people and goods.

MaaS is the DX of public transportation based on the data integration of multimodal mobility services. Table **1** briefly summarizes the primary national and international interpretations of MaaS.



Map Legend:
※ Indicates regions selected in Reiwa 1st year (2019) and Reiwa 2nd year (2020)
※ Indicates that there are other projects in Reiwa 2nd year (2020)

Japan MaaS Demonstration Experiment Promotion and Support Project in 2019 (19 projects)	Japan MaaS Demonstration Experiment Promotion and Support Project in 2020 (36 projects)
A. Hokkaido Hakodate Area	1. Hokkaido Tokachi Area
B. Hokkaido Asahikawa City	2. Surrounding area of Hokkaido Hakodate City
C. Miyagi Prefecture Sendai City	3. Hokkaido Otaru Area
D. Chiba Prefecture Kashiwa City	4. Fukushima Prefecture
E. Tokyo Metropolitan Area	5. Ibaraki Prefecture Tsukuba City
F. Toyama Prefecture Toyama City	6. Ibaraki Prefecture Tsukubamirai City
G. Nagano Prefecture Matsumoto City	7. Tochigi Prefecture Utsunomiya City
H. Aichi Prefecture Nagoya City	8. Gunma Prefecture
I. Kyoto Prefecture Kyoto City	9. Saitama Prefecture Kumagaya City
J. Osaka Prefecture Osaka City	10. Kanagawa Prefecture Fujisawa City
K. Hyogo Prefecture Awaji Island Area	11. Kanagawa Prefecture Sagamihara City
L. Nara Prefecture Nara City	12. Kanagawa Prefecture Yokohama City
M. Kagawa Prefecture Takamatsu City	13. Kanagawa Prefecture Kawasaki City
N. Ehime Prefecture Matsuyama City	14. Toyama Prefecture Takaoka City
O. Fukuoka Prefecture Fukuoka City	15. Ishikawa Prefecture Kanazawa City
P. Fukuoka Prefecture Kitakyushu City	16. Nagano Prefecture
Q. Kumamoto Prefecture Kumamoto City	17. Shizuoka Prefecture
R. Kagoshima Prefecture Kagoshima City	18. Shizuoka Prefecture Fujinomiya City
S. Okinawa Prefecture Naha City	19. Shizuoka Prefecture Izu Peninsula Area
	20. Aichi Prefecture Toyota City
	21. Mie Prefecture Matsuzaka City
	22. Shiga Prefecture Otsu City
	23. Kyoto Prefecture
	24. Osaka Prefecture Sakai City
	25. Osaka Prefecture
	26. Hyogo Prefecture Kobe City
	27. Hyogo Prefecture
	28. Tottori Prefecture Yonago City
	29. Hiroshima Prefecture
	30. Kagawa Prefecture Takamatsu City
	31. Kagawa Prefecture
	32. Ehime Prefecture Matsuyama City
	33. Fukuoka Prefecture
	34. Saga Prefecture
	35. Nagasaki Prefecture
	36. Okinawa Prefecture

Fig. (1). Japanese MaaS promotion and support project (FY2019-2020).
Source: Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan (2022), “Promotion of Japanese MaaS: Formation of a MaaS Model”, https://www.mlit.go.jp/sogoseisaku/japanmaas/promotion/model/index.html (07/15/2024).

Table 1. Interpretations on MaaS.

Interpreter	Interpretation on MaaS	Point
Heikkila, Finland (2014)	In a competitive mobility operator market, an organization that provides mobility services as a separate, flexible service is called mobility as a service (MaaS). The variety of services offered by mobility operators meets all mobility demands, thus reducing the need to own a car.	Mobility operators provide comprehensive mobility services **(Value creation oriented)**
European Organization for Intelligent Transport Systems (ERTICO) (2018), which defines ITS industry standards.	It is "the integration of various forms of transport services into a single mobility service accessible on demand. For the user, MaaS offers added value through a single application to provide access to mobility, with a sole payment channel instead of multiple ticketing and payment operations. s. MaaS aims at providing an alternative to dependency on car ownership that may be seen as convenient, flexible, reliable and cheaper." (p.3).	Provides access to mobility with a single payment channel through an application **(Value creation oriented)**
International Union for Public Transport (UITP) (2019), a non-profit organization that advocates for the promotion of public transport use.	"MaaS is the integration of, and access to, different transportation services (such as public transport, ride-sharing, car-sharing, bike-sharing, scooter-sharing, taxi, car rental, ride-hailing and so on) in one single digital mobility offer, with active mobility and an efficient public transport system as its basis. This tailor-made service suggests the most suitable solutions based on the user's travel needs. MaaS is available anytime and offers integrated planning, booking and payment, as well as a route information to provide easy mobility and enable life without having to own a car."	Tailor-made services offer the best solution based on the user's mobility demands **(Value creation + solution-oriented to local issues)**
Public Transport and Logistics Policy Councilor Division,Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan (2023)	The new mobility service, MaaS, is based on a service that optimally combines multiple public transportation and other mobility services to meet the trip-by-trip mobility needs of individual local residents and travelers, and provides search, reservation, payment, and other services all in one place, while various initiatives are underway in various regions of Japan. Various initiatives are underway in various regions of our country."	Optimal combination of multiple public transportation and other mobility services, including search, reservation, and payment, all in one place **(Value creation + solution-oriented to local issues)**
Office of Information and Communication Economy, Information and Communication Policy Division, Information and Communication Administration Bureau, Ministry of Internal Affairs and Communications, Japan (2018)	When traveling by train, bus, plane, or other means of transportation, it is now possible to search for routes that cross these modes of transportation, but reservations and payment of fares must be made individually to each operator. MaaS is a service based on the concept of making it possible to search, book, and pay for transportation all at once from a smartphone or other device, greatly increasing user convenience and helping to solve problems such as traffic congestion in urban areas, environmental problems, and vulnerable road users in rural areas by making transportation more efficient. MaaS is a service based on the idea of helping to solve problems such as urban traffic congestion, environmental problems, and vulnerable road users in rural areas.	Services that seek to help solve regional transportation issues by improving user convenience and travel efficiency. **(Value creation + solution-oriented to local issues)**

Sources: Heikkilä, S. (2014), ERTICO (2018), UITP (2019). Ministry of Land, Infrastructure, Transport and Tourism, Policy Bureau, Public Transport and Logistics Policy Councilor Division (2023), Ministry of Internal Affairs and Communications, Information and Communication Economy Office, Information and Communication Policy Division, Information Distribution Administration Bureau (2018).

As shown in Table **1** [10, 27-31], MaaS-related interpretations can be divided into two main types based on the interpreters' different positions and perspectives. One interpretation focuses on increasing users' willingness to use public transportation by improving user convenience (= value creation), and it emphasizes the importance of market forces. The other is problem-solving-oriented MaaS, which considers MaaS as a means to address regional issues from the perspective of community development, viewing the region as a whole [33, 34].

Market-oriented MaaS is based on seamless movement through the data integration of multimodal mobility services centered around existing public transportation. It aims to create value beyond the opportunity cost of self-produced transportation services, such as labor, time, fuel, parking fees, insurance, maintenance and repair costs, and taxes related to transportation equipment and fuel. Regarding the basic concept, Tachibana (2023) describes the service as akin to a "travel agency for daily transportation" [32].

In contrast, MaaS, designed to solve regional issues, leverages the integration of data from existing multimodal mobility services centered on public transportation. It aims to connect data from all related services scattered throughout the region to enhance transportation functionality. The goal is to create transportation communities that include not only the local population and residents but also individuals engaged with the area in various ways [35]. It aims to revitalize the region and improve the well-being of its people and society by optimizing and streamlining the flow of people and goods.

3. POLICY IMPLICATIONS OF MAAS

3.1. The Age of "Traffic Coordination Theory

Furthermore, to address the "creative destruction" brought about by the recent transportation revolution—characterized by the diversification of business models and the integration of information technology in transportation—it is necessary to consider the policy implications of MaaS in the context of DX for public transportation. First, we need to review the Japanese domestic policy practices—specifically the comprehensive transportation policies from 1955 to 1985—in response to the "creative destruction" caused by the earlier transportation revolution. We also examine the transportation coordination theory that served as the theoretical background during this period. Then, we review the experiences and lessons learned from this period.

The traffic coordination theory, which has been discussed and developed in Western countries since the 1930s, is a framework for analyzing the "competitive transportation market phenomenon" triggered by the former transportation revolution. This revolution was marked by the advent of the automobile at the end of the nineteenth century and the mass production of Ford's Model T in 1908. In Japan, this theory has been shaped by numerous studies in fields such as urban planning, traffic engineering, and transportation policy [15, 36-40]. This paper explores the significance of domestic transportation coordination theory from the perspective of transportation policy.

3.1.1. Historical Development of Comprehensive Transportation Policy (two reports)

The 1971 Report of the Japan Transport Policy Council, titled "Report on the Comprehensive Transport System" (hereafter referred to as the "1971 Report"), was issued during a period of rapid postwar growth when the aim of economic policy was "how to efficiently allocate limited resources and promote economic development." The comprehensive transportation policy was similarly based on "efficiency in resource allocation" as its fundamental policy objective. Although the 1971 Report aimed to establish a comprehensive transportation system emphasizing fairness and the preservation of the natural environment (ecosystem), the policy goals were focused on the efficiency of re-source allocation and the development of social infrastructure for transportation efficiency.

After the 1971 Report, the economy experienced two unforeseen oil shocks and shifted from high growth to stable growth. Immediately after the first oil crisis, the comprehensive transportation system theory prioritized consumer sovereignty in addressing spatial and environmental problems and energy resource issues and emphasized the need for policies guiding the creation of an efficient national-level transportation system. The "logic of planning" prevailed over the "logic of the market" of the 1971 report.

Then, the 1981 Japan Transport Policy Council Report, titled "Basic Direction of Comprehensive Transport Policy Based on Long-Term Perspective" (hereafter referred to as the "1981 Report"), presented comprehensive transportation policy issues during the period of stable growth from eight perspectives. In this period, the theory of resource and energy constraints on economic and social development was introduced, incorporating a shift in the social consensus and the goals of a comprehensive transportation policy. Consequently, the comprehensive transportation policy between 1955 and 1985 was formulated and implemented by the national government in response to these two reports.

3.1.2. Theoretical development of integrated transportation policy

The theoretical development of comprehensive transportation policy in Japan is known as the theory of transportation coordination, which has two representative interpretations: (1) equal footing theory and (2) appropriate field theory.

3.1.2.1. Equal Footing Theory

Equal footing theory began to be discussed in the 1960s, when Japan's economy entered a period of rapid growth and subsequently played a role as one of the arguments for the 1946 Report. The theory originated from an awareness of the cost disparities between road and rail transportation corridors. It was based on the fundamental economic principle that the most efficient allocation of resources occurs through free consumer choice in a fair competitive market and that interference with consumer sovereignty is undesirable.

3.1.2.2. Appropriate Field Theory

The appropriate fields theory was skeptical about the rationality of leaving resource allocation entirely to the market or the appropriateness of modal split through competition, presenting a policy logic different from that of the equal footing theory. While equal footing theory focused on revitalizing competitive markets by equalizing competitive conditions, appropriate fields theory considered other factors excluded from the market (market failure). It emphasized the necessity of establishing an appropriate sharing relationship through government-led demand guidance and management and called for comprehensive government control [38].

The "comprehensive transportation policy," which was designed to mitigate the "destructive effects" of motorization during this transport revolution and to rescue the railroads, came to an end in the 1990s with the "abandonment of integration in the country" and the "increasing emphasis on the market" [40]. However, as it was an attempt to curb "escapable social cost" it should be evaluated as an important part of the history of transportation policy [39].

The escapable social costs are those negative externalities or costs imposed on society by a given economic activity or decision that can be avoided or reduced by the individual or entity responsible for the activity. These costs are "escapable " because the individual or entity responsible for them has the option to avoid or reduce them but chooses not to. Lewis, W.A. (1949) states, "If two industries can perform the same service, one at a lower social cost than the other, the cheaper should perform it, unless the superior quality of the service offered by the other is worth more than the difference in cost-allowing, *e.g.*, for differences of speed in transport." He proposed this as the second principle of the transport coordination theory [41].

3.2. "Seamless Public Transportation" and "Intermodal Transportation

Subsequently, motorization in Japan progressed further. By 1990, freight vehicle transportation accounted for 90.2% of the total tonnage. In the late 1990s, the number of private passenger cars per household in Japan had exceeded 1. Against this backdrop, seamlessness [42] in the public transportation sector was advocated. This included barrier-free measures, expansion of transfer fare discounts, the establishment of common boarding passes, and, in the railroad sector, same-platform transfers, mutual direct operations, and connection timetables. The seamless public transportation system eliminated "seams" between transportation facilities and within transportation terminals in terms of both hardware and software, promoting the use of public transportation by improving the travel experience. Conversely, in the logistics field, intermodal transportation [43], which is also referred to as "intermodal transportation" [44] and combines multiple modes of transportation under one contract to provide door-to-door transportation without transshipment, was proposed. Since the 1990s, intermodal transportation in the logistics sector and seamless public transportation have provided more convenient and efficient travel for users (passengers and shippers) by effectively coordinating different modes of transportation and transportation services. Their philosophy includes not only respect for consumer sovereignty but also multidimensional perspectives such as environmental considerations, effective utilization of transportation social capital, and job creation.

3.3. "Transportation Integration" and MaaS

A study commissioned by the European Commission, NEA, OGM, and TSU (2003) provides a typical interpretation of transportation integration [45]. It defines integration as "an organizational process that unites the planning and provision of components of the transportation system across modes of transportation, modes of management, transit operators, and related agencies, with the aim of increasing net social benefits" [26, 46, 47]. J. Preston (2012) revisited this definition in "Integration for Seamless Transport" by the Organization for Economic Cooperation and Development (OECD). He outlined a progression from "integration of public transport information," "integration of public transport services," and "integration of public transport fares" to "integration of public and private transport," "integration of passenger transport and freight transport," and "integration of transport operators" [46]. This progression further extends to "integration of land use," "integration of education, health, and social welfare services," and "integration of environmental and economic policies". The goal of transport integration is depicted as achieving "integrated and sustainable transport" through nine phases of integration, spanning from the policy level to the policy goal level [46, 48].

Later, with the advent of car-sharing apps and shared mobility, the concept of sharing became widespread and deeply ingrained globally. The potential for further streamlining transportation through the integration of mobility information became evident, leading to the emergence of a digital version of transportation integration at the policy level known as MaaS.

In this way, we observe a cyclical interpretation aimed at organizing, developing, and integrating relationships between transportation modes in Japan, based on three key concepts: the domestic "transportation coordination theory" devised as a remedy for railroads during the earlier transportation revolution; the concepts of "seamless public transportation" and "intermodal transportation," which focus on improving transport efficiency and effectiveness through the coordination of passenger and freight transportation modes at the policy level against the background of the "abandonment of national integration" since the 1990s; and the idea of "transportation integration" as a means to achieve "sustainable transportation" through a bottom-up, step-by-step integration from policy measures to policy goals, influenced by European countries' transportation policies. Furthermore, MaaS at the policy level includes not only organizing and building relationships between transportation modes but also aspects related to community-based transportation planning, creating sustainable local communities, and revitalizing regions, thus encompassing a multifaceted perspective. Therefore, in section (4.1), we outline the current state of social implementation of next-generation transportation services in Japan, focusing on MaaS practices, and consider the potential for a new interpretation at the policy level of "transportation integration."

4. SOCIAL IMPLEMENTATION OF NEXT-GENERATION TRANSPORTATION SERVICES IN JAPAN

4.1. Current Status of Next-generation Transportation Services in Japan

MaaS aims to provide integrated transportation services from the user's perspective and can be classified into five integration stages [49], from level 0 to level 4. In Japan, transit and route guidance services were already available before 2019, and transportation IC cards, mainly in urban areas, allowed users to pay fares for multiple mobility services with a single card. Additionally, some mechanisms allowed unlimited rides on trains and buses, meaning that MaaS Level 2 and Level 3 were partially realized in ways that did not involve applications [13, 43, 50-53].

For this reason, with the realization of Level 3 and Level 4 MaaS in mind, the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) established the MaaS Demonstration Experiment Promotion and Support Project in 2019. As shown in Fig. (**1**) and Table **2**, this initiative developed the Japanese version of the MaaS promotion and support project, encompassing 19 projects in FY2019, 36 projects in FY2020, 12 projects in FY2021, and 6 projects in FY2022 [54]. Based on the adoption status of the promotion and support projects from FY2019 to 2021, the "combination of multiple modes of transportation" and "collaboration between companies and local governments" have been important factors in the adoption or rejection of these projects. The size of the local population and the participation of the main public transportation operator in the region (*e.g.*, railroad companies) are also likely to influence the decision-making process. The size of the local population and the participation of major regional public transportation operators (*e.g.*, railway companies) are also expected to be key factors in the decision-making process [55-57]. Additionally, starting in FY2023, MaaS-related projects have been classified as part of smart city initiatives, making support from the perspective of community-based transportation and town planning an important aspect for the future (Fig. 2).

Table 2. Government MaaS-related projects in FY2023.

Government Department	Ministry of Economy, Trade and Industry (Automobile Division, Manufacturing Industries Bureau, ITS and Automated Driving Promotion Office)	Ministry of Land, Infrastructure, Transport and Tourism (Mobility Services Promotion Division, Policy Bureau)
Project name	New Regional MaaS Creation Promotion Project	Japanese Version MaaS Promotion and Support Project
Outline	Promotion of advanced MaaS demonstrations that contribute to the creation and horizontal development of advanced and sustainable business models for the social implementation of new mobility services and the resolution of mobility issues in the region.	Promote coordination of MaaS initiatives in each region and cooperation among transportation operators and operators in other fields within each region to realize highly comfortable and convenient transportation services that transcend areas and businesses.
Budget for FY2023	Several hundreds of millions of yen	0.55 billion yen
Number of projects selected in the past	2019: 13 projects 2020: 16 projects 2021: 14 projects 2022: 11 projects	2019: 19 projects 2020: 36 projects 2021: 12 projects 2022: 6 projects
Main support targets	Creating advanced and sustainable business models to solve regional issues and to horizontally expand nationwide Support for wide-area, advanced MaaS and other initiatives.	Support for the introduction of new payment methods and new mobility services, and support for the digitization of operation information, *etc*.

Source: Based on the Cabinet Office website, "Overview of Smart City-related Projects in FY2023 (Projects Subject to Joint Review)", https://www8.cao.go.jp/cstp/stmain/pdf/r5_sc_besshi1.pdf (07/15/2024).

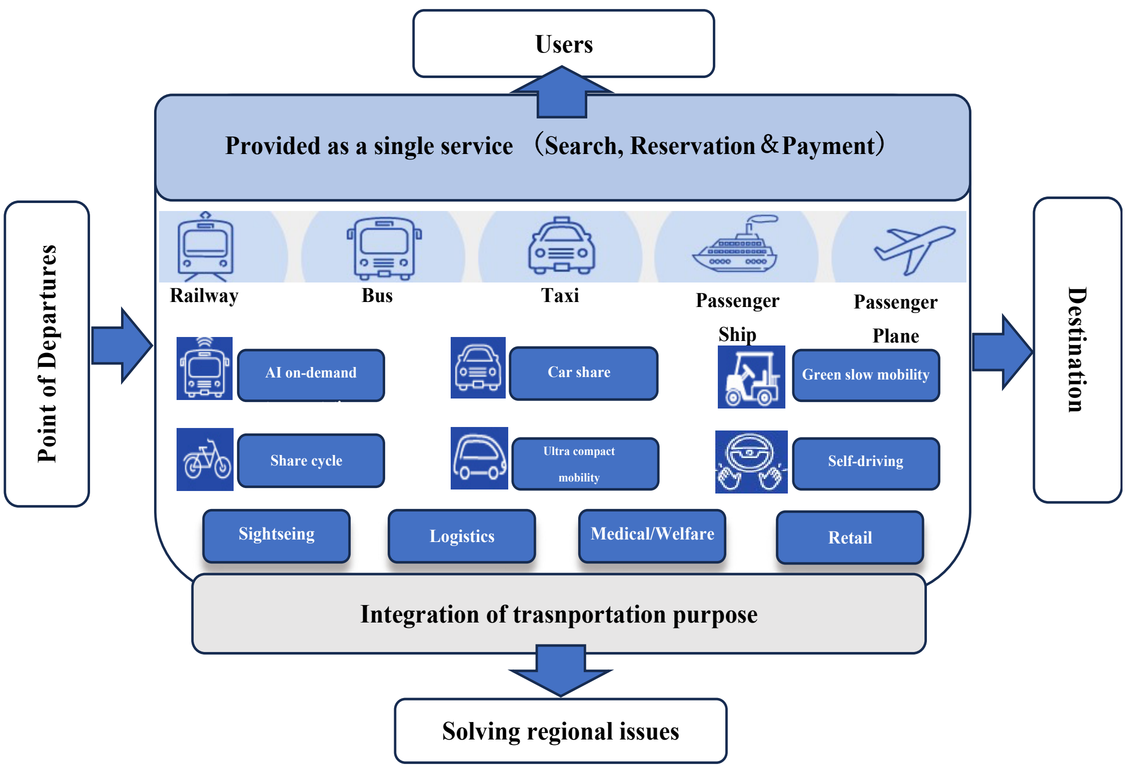


Fig. (2). The concept of Japanese MaaS.
Source: Prepared by the author, based on the Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan (2022), "Promotion of Japanese MaaS: Formation of a MaaS Model," https://www.mlit.go.jp/sogoseisaku/japanmaas/promotion/index.html (07/15/2024).

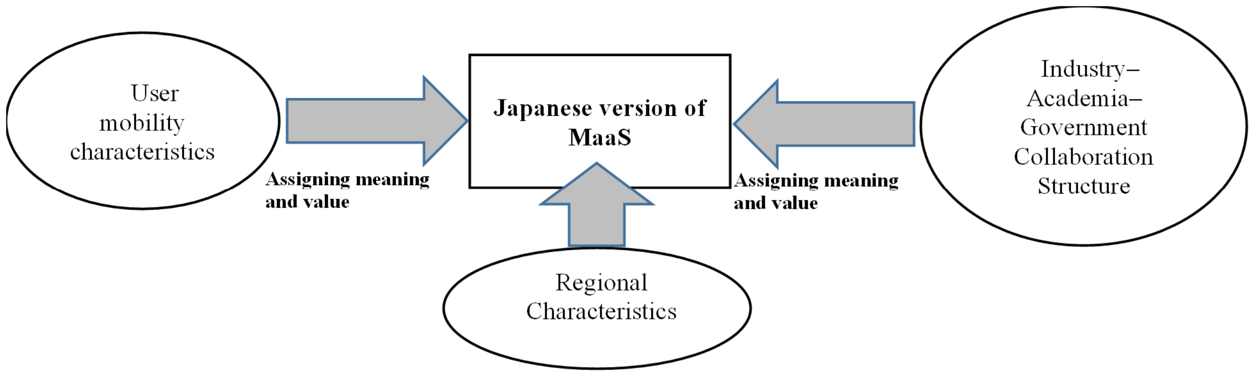


Fig. (3). Challenges for Next-generation Transportation Services - Using the Japanese version of MaaS as an example.

Meanwhile, Tokyu Corporation and East Japan Railway Company collaborated in conducting Japan's first tourism-oriented MaaS verification experiment in the Izu area in April 2019 as a representative initiative on the transportation operator side [58]. They developed a dedicated application, “Izuko,” for domestic and international tourists. This application allows users to search for, make reservations, and pay for railroads, buses, AI on-demand rides, bicycle rentals, and other transportation services, all with a single smartphone. In Kyushu, the MaaS application “my route” was fully introduced in November 2019 in collaboration with Toyota Motor Corporation, the Nishitetsu Group, and JR Kyushu. The application provides not only multi-modal route searches, transportation reservations, and payments but also information on stores and events that can serve as travel purposes. The aim was to support smooth transportation in Fukuoka City, Kita-kyushu City, and surrounding areas and to contribute to creating a bustling city by offering information on stores and events alongside multimodal transportation searches, reservations, and payment options [13].

4.2. Challenges for Next-generation Transportation Services in Japan

In reviewing the domestic practice of MaaS in Japan, which is a key principle of next-generation transportation services, the Japanese version of MaaS should be approached from three perspectives: understanding regional characteristics, understanding user mobility characteristics, and fostering industry-academia-government collaboration (Fig. **3**).

4.2.1. Understanding the Characteristics of the Region

In recent years, the mobility disparity between the three major metropolitan areas and the rest of Japan has become more pronounced, leading to the real problem of ensuring foot traffic in depopulated areas. In rural areas with initially low user numbers, it is necessary to explore sustainable MaaS business schemes that suit each region’s characteristics, such as creating tourism demand and introducing demand-driven transportation. Therefore, the Japanese version of MaaS should not be implemented through a top-down approach, as was done during the era of transportation coordination theory. Instead, it should begin with an understanding of the existing public transportation status in each region, the residents’ needs, and rediscovery and reinterpretation of regional characteristics, ultimately creating individual success stories through a bottom-up approach that will be used to develop individual best practices

4.2.2. Understanding user Mobility Characteristics

Users are at the heart of MaaS, and their mobility behaviors significantly influence the success of transportation services. Changes in societal values—such as a growing emphasis on environmental sustainability, health, and convenience—affect how individuals choose to move within their communities.

The government and MaaS operators must closely monitor shifts in user preferences, such as:

4.2.2.1. Preference for Sustainable Transportation

Increasing awareness of climate change has led to greater interest in carbon-neutral transportation options. Users may favor services that offer lower environmental impact, such as electric vehicles or active transportation modes like walking and cycling.

4.2.2.2. Adoption of Pedestrian-centric Urban Design

There's a growing trend toward designing cities that prioritize pedestrian movement and reduce reliance on cars. MaaS solutions should align with this philosophy, promoting modes that support walkable communities.

4.2.2.3. Demand for Personalized and Convenient Services

Users expect mobility solutions that are tailored to their individual needs, offering convenience and flexibility.

As these values evolve, the potential market for new mobility services expands. For instance, a community with a strong interest in sustainability may be more receptive to MaaS solutions that integrate bike-sharing and electric vehicle options. Recognizing and adapting to these shifts enables MaaS providers to design services that resonate with users, enhancing adoption rates.

Moreover, the government's role is pivotal in facilitating this adaptation. Policy frameworks should support innovation in transportation services, incentivize sustainable practices, and ensure that regulations are flexible enough to accommodate emerging technologies and business models.

4.2.3. Perspectives on Industry-academia-government Collaboration

Effective MaaS implementation requires collaboration across sectors. While individual MaaS practices tailored to regional characteristics are valuable, they often face challenges such as limited service scope, low public awareness, and increased costs due to duplicated system development [34].

Furthermore, to overcome these issues, it is crucial to conduct cross-regional analyses and share best practices. Collaborative efforts among transportation companies, universities, research institutions, and local governments can facilitate this process. Universities and research institutions can contribute through:

4.2.3.1. Data Analysis and Research

Providing insights into user behavior, transportation patterns, and technological advancements.

4.2.3.2. Innovation and Development

Assisting in developing new technologies and platforms that enhance MaaS services.

4.2.3.3. Policy Recommendations

Offering evidence-based guidance to policymakers on effective strategies for MaaS implementation.

Local governments can support MaaS diffusion by:

4.2.3.4. Regulatory Support

Creating policies that enable flexible service provision and encourage private-sector participation.

4.2.3.5. Public Engagement:

Facilitating community input to ensure services meet local needs.

4.2.3.6. Infrastructure Development

Investing in the necessary infrastructure to support integrated transportation services.

Transportation companies can contribute by:

4.2.3.7. Service Integration

Opening their systems for integration with MaaS platforms.

4.2.3.8. Data Sharing

Providing access to transportation data to improve service planning and user experience.

An example of successful industry-academia-government collaboration is the "Smart Mobility Challenge" initiated by MLIT, which brings together stakeholders to develop and test innovative mobility solutions in real-world settings. Such initiatives encourage knowledge exchange, reduce redundant efforts, and accelerate the deployment of next-generation transportation services.

CONCLUSION

From a global perspective, the first transportation revolution refers to the emergence and development of railroads and steamships in the early nineteenth century, while the second transportation revolution involved the rise of automobiles and airplanes from the late nineteenth to the twentieth century. The author believes that the third transportation revolution is characterized by the digital transformation of transportation services through (1) the diversification of business models and (2) the transformation of transportation equipment into information terminals, driven by technological innovations such as IoT and Artificial AI.

In addition, To explore how transportation policy should adapt to the challenges presented by this third revolution, this paper clarifies the evolution of transportation services and introduces the concept of next-generation transportation services. Moreover, by drawing from the empirical knowledge of transportation coordination theory, which emerged during the second transportation revolution, this study presents the policy implications of MaaS as a foundational element for the development of smart cities.

Looking ahead, the successful social implementation of next-generation transportation services, such as MaaS, will increasingly depend on addressing regional-level needs. A practical approach must be taken, which involves a deep understanding of regional characteristics, user mobility patterns, and socio-economic contexts. Furthermore, verifying the effectiveness of projects through cross-sector collaboration between industry, academia, and government across different regions will be essential for ensuring scalability and adaptability.

Future research should also focus on advancing theoretical frameworks for transportation policies, particularly in addressing the social costs that can be avoided or minimized (escapable social costs) through strategic interventions. Additionally, there is a need for further exploration into integrating MaaS with other urban systems, such as energy and communication networks, to create truly holistic smart cities. Developing innovative funding and business models, as well as ensuring equitable access to MaaS services, will be crucial for maximizing the societal benefits of this transportation revolution.

AUTHORS' CONTRIBUTION

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

LIST OF ABBREVIATIONS

eVTOL	=	Electric Vertical Take-Off and Landing
CASE	=	Connected, Automated, Shared, Electric
MaaS	=	Mobility as a Service
IoT	=	Internet of Things
AI	=	Artificial Intelligence

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