Foundational Transit Innovation for Mobility-as-a-Service (MaaS) in Asia

Kathy Zhang

Key Takeaways

- To deliver quality transportation service to more people, transit agencies have incrementally modernised their processes with digital ticketing and payment systems, intermodal connections (for example, bus to rail), and intercity connections (for example, regional transport).
- In the cities examined in this paper (Seoul, Singapore and Taipei), transit adoption among urban residents is already quite high. As such, cities like Taipei are interested in MaaS as a value add for replacing inter-city car trips via transit integration with shared modes such as car rental, scooters etc., in addition to exploring intra-city first-mile last-mile connections.
- Digital services (like payments, and mapping for route planning) are essential for transportation service delivery, and payments (credit card companies) and mapping tools (like Google Maps) are key stakeholders in MaaS collaborations.
- Transit remains the backbone of sustainable urban transport, and transportation agencies and regulators largely hold the power in selecting which private operators to work with and integrate into agency-managed transit apps.
- An effective MaaS program requires complex cross-sector cooperation between a large number of stakeholders, a robust public transit system, and technical and management capacity for piloting and implementation.
- For governments, smartphone applications offer two-way transport management – real time information can be pushed to travelers to optimise transportation systems and aggregate data can help inform transportation planning and policies.

1 Introduction

Around the world, both city governments and private companies are building transportation platforms that aggregate multiple modes (transit, bikes, scooters, ride hailing, car sharing, etc.), also known as Mobility-as-a-Service (MaaS). To the end user, MaaS often takes the form of a mobile app that offers more attractive alternatives to auto use. MaaS also holds the promise of providing cities with a range of sustainability and efficiency benefits, including data for real-time mobility management, higher transit ridership, reduced congestion and transport-related emissions. Given that MaaS is often a combination of public (for example, transit) and private (for example, ride hailing) service providers, integration across sectors presents new and complex challenges. Using case studies from Seoul, Singapore, and Taipei in the past two decades, this paper examines how incremental transit advancements in ticketing and payments have laid the foundation for MaaS.

In the existing literature, MaaS is broadly defined as "a single interface that combines different transport modes to offer consumers the possibility to get from A to B in a flexible, personalized, on-demand and seamless way."[1] Additionally, researchers have started to consider the social, political, and economic contexts that inform key differences in MaaS programmes around the world. Currently, over 70 cities globally are formally exploring or piloting MaaS, with the majority of such cities being in Europe.[2]

A multi-region research collaborative led by Araghi et al. reviewed the key drivers and barriers across the public sector, private sector, and travelers in moving up the levels of MaaS integration, which include journey planning, ticketing, and payment. The key barriers to MaaS development included resistance to data sharing and lack of incentive to cooperate among operators with market power. In effective MaaS schemes, stakeholders from the public and private sectors play to their distinct strengths – such as project financing, technical implementation, and monitoring and evaluation – to expand connectivity among local transport options.

1 Reyes García, J. R., Lenz, G., Haveman, S. P., & Bonnema, G. M. (2019). State of the Art of Mobility as a Service (MaaS) Ecosystems and Architectures – An Overview of, and a Definition, Ecosystem and System Architecture for Electric Mobility as a Service (eMaaS). World Electric Vehicle Journal, 11(1), 7.

2 Chang, S. K. Jason, Hou Yu Chen, and Hung Chang Chen. (2019). "Mobility as a Service Policy Planning, Deployments and Trials in Taiwan." IATSS Research 43 (4): 210–18.

2 Characteristics of MaaS Systems

2.1 Technological convergence

MaaS evolved from a combination of Intelligent Transportation Systems (ITS) with advancements in connected devices and real time data. MaaS builds upon a suite of existing technologies from transportation, payments, telecommunications, and mobile application which "enable integration of information, booking and payment, and support operational flexibility for near-real-time demand-responsiveness ... proliferation of smartphone apps providing real-time transport information, either crowdsourced, utilising open data or public authority/operator Application Programming Interfaces."[3]

2.2 Ecosystems for collaboration and incentives for innovation

For the user, MaaS can provide more convenient access to their location's transportation options, including increasing numbers of modes that are more flexible than fixed route transit, such as bike share and ride hailing. MaaS implementation demands novel forms of private-to-private collaboration. The projects are often so large and complex that no one company can supply everything with their technology, and it requires partnerships and consortia efforts to win government bids for MaaS projects. Thus, trust among private actors underpins the possible types of integrations across journey planning, ticketing, and payments.

In MaaS development, a new category of technology providers plays the role of aggregators, and they perform the key function of "offering the one-stop integrative function. Brokers form the conduit for connecting demanders of transport service and suppliers of the transport asset/capacity by facilitating the delivery of physical transportation."[4] Dominant search engines with map

3 Pangbourne, K., Mladenović, M. N., Stead, D., & Milakis, D. (2020). Questioning mobility as a service: Unanticipated implications for society and governance. Transportation Research Part A: Policy and Practice, 131(January 2019), 35–49.

4 Wong, Y. Z., & Hensher, D. A. (2020). Delivering mobility as a service (MaaS) through a broker/aggregator business model. Transportation, (0123456789).

functionally are emerging as potential "super aggregators." Many people still think of Google as a search engine, or an organiser of information. However, Google (and its parent company Alphabet) has made significant investments in rendering the physical world more legible, most notably through Google Maps.

Transportation policy scholars note that transport projects generally have high initial investments and are monopolistic: "MaaS projects have external societal benefits which are not easily internalized. Therefore, the public sector has an obligation to provide enough resources for a necessary service such as open data hub by considering the external effects and the potential subsidy schemes."[5] As such, government intervention and oversight are needed to manage such services for the public interest.[6] Singapore and Seoul pursued public–private partnerships (PPPs) to marry the financial and institutional backing of the government with the technical and operational capacity of the private sector.

2.3 Economic and governance

MaaS holds the potential to shape travel behavior at a more granular level (by time, geography, and distance) than ever before: "since on-demand mobility services are often dynamically tailored to different individual preferences and contexts (for instance, time-of-day, supply and demand matching), disaggregate behavioral models are essential for the accommodation of their complex dynamics, which enables the quantification of user benefits and overall transportation impacts (such as congestion and other externalities)."[7]

Like cities with the implementation of congestion charging in the 2000s and 2010s, MaaS providers will experiment with different pricing schemes, which may include subscriptions and incentives. A subscription-based model, in particular, will prompt users to "make decisions on three levels: they decide whether to own a car in the long run, whether to buy a subscription to alternative modes in the medium run, and daily mode choice is also endogenous in the short run."[8]

A primary concern with private sector ownership of MaaS is harmful monopolistic behavior, which might include deterring new entrants, closing off platform access, and increasing prices. As such, the type of governance model will help to ensure public sector oversight in terms of which transport modes are being prioritised in a MaaS environment.

2.4 Data and privacy

Data privacy and security are key conditions for successful implementation for MaaS, which "represent complex networks of public and private service providers and users, with a multiplicity of data resources including open data (such as public transport schedules), commercially sensitive data (including fees and service availability), and

5 Chang, S. K.Jason, Hou Yu Chen, and Hung Chang Chen. (2019). "Mobility as a Service Policy Planning, Deployments and Trials in Taiwan." IATSS Research 43 (4): 210–18.

6 Park, J. Y., & Kim, D. (2013). Korea´s Integrated Fare and Smart Card Ticket System.

7 Xie, Y., Danaf, M., Azevedo, C. L., Prakash, A. A., Atasoy, B., Jeong, K., … Ben-Akiva, M. (2019). Behavioral Modeling of On-Demand Mobility Services: General Framework and Application to Sustainable Travel Incentives. Transportation Research Board 98th Annual Meeting, (0123456789), 1–24.

8 Marketing, P. T., Transport, I. P., Transit, P., Integration, M., Cities, M., Transportation, P., & Graham, D. (2019). Transportation Research Record MaaS Economics : Should We Fight Car Ownership with Subscriptions to Alternative.

personal user data (such as financial information and travel plans)."[9] Furthermore, user travel data may be monetised as auxiliary forms of revenue, undermining the core priorities of transportation service delivery: "MaaS has the potential to create a new market by selling data analysis to many different actors, not only the mobility service providers and urban authorities but potentially to other private companies, such as retailers."[10]

9 Cottrill, C. D. (2020). MaaS surveillance: Privacy considerations in mobility as a service. Transportation Research Part A: Policy and Practice, 131(September 2019), 50–57.

10 Pangbourne, K., Mladenović, M. N., Stead, D., & Milakis, D. (2020). Questioning mobility as a service: Unanticipated implications for society and governance. Transportation Research Part A: Policy and Practice, 131(January 2019), 35–49.

3 Case Studies

To illustrate the evolution of MaaS programmes in different Asian city contexts over the past decades, this paper traces urban transport policy, planning and implementation in Seoul, Singapore and Taipei. The three cities selected as case studies have a great deal in common – they are large, densely populated, economic and political capitals of their country. The governments in Seoul, Singapore, and Taipei have recognised that concerted intervention around congestion was needed and invested early in technology, partnership structures, and strategic planning to shift residents and visitors to more efficient transport. All three cities had invested in real-time traffic management and transit information systems, and digitising transit fare collection and payment as early as the 1990s.

3.1 Seoul

Seoul's population grew dramatically in the late 1990s, expanding from 2 million to 10 million in just three decades. This growth and the consequent spurt in car use strained the capacity of the roadways significantly, which slowed and worsened bus service.

Around 2000, a public transport reform plan prioritised integrating the then disparate bus and subway systems and replaced the privatised bus industry with a quasi-public system which gave city government authority to intervene on operations and management issues. Policy makers identified fare integration between subway and bus as one key improvement that can make public transit more appealing relative to car use.[11] The primary policy goals driving this intermodal fare system include: reducing user fares, improving system connectivity, and increasing ridership, user satisfaction, and operational efficiency (digital payment requires less time than cash payment). The multi-jurisdictional coordination of the bus network was a challenge and required alignment across multiple agencies in Seoul and the nearby municipalities of Incheon and Gyeonggi.

In 1996, Korea introduced the first smart card for the Seoul bus systems. Initial operational challenges included a lack of cooperation and interoperability among operators. In 2004, Korea launched a new smart card (T-money) that could be used for subway, bus, and ultimately taxi services. Eventually, the card could be used to pay for transportation in 60 cities across the country. The smart card was a means for riders to access an integrated fare system, where users could combine subway, bus, and taxi modes on a single trip. The uptake for smart card

11 Lee, S., & Gyeong, Y. (2017). One Card Fits All: Integrated Public Transport Fare System. Seoul Policies That Work: Transportation.

use was swift, with utilisation rates reaching 90% of the Seoul population by 2006. In 2007, the smart card expanded to include taxi payment. The smart card stakeholders also recognized the application for non-transport purposes early, such as local commerce. In 2009, a single-use (deposit refunded upon return of the card) card ticket was introduced, which pushed the smart card utilisation rate to close to 100%.[12]

The smart card presented significant benefits for the key stakeholders in public transit (users, operators, and agencies). The card enabled digital fare collection, which offered new technical capabilities for distance and zone-based fare, providing transit capacity management at a newly granular level. For the user, the system enabled transfers among neighboring transit systems without paying additional fees. The fare could also be settled more efficiently on the back end, with revenue distributed to the appropriate operators in a multi-operator suite of options.

In 2003, the Seoul Metropolitan Government (SMG) established the Korea Smart Card Co., Ltd (KSCC) to service integrated mass transportation networks across Korea. SMG remains the largest shareholder of KSCC and provides policy oversight, though day-to-day operations are managed by the second largest shareholder LG CNS (selected by SMG via a competitive bid). SMG deliberately created financial incentives for the private operators it supervised, which were permitted to "take the settlement and clearing commission fees as its main source of income and to create profits by expanding the smart card ticket project to cover such areas as taxi fares."[13] The government also played the role of a standards setting body and introduced a certification for new devices and services seeking integration with smart card tickets.

When taking office in 2013, Mayor Wonsoon vowed to transition Seoul from a car-centric city into a people-centric city, noting that "citizens want convenient, reliable, and diverse personal mobility choices, including bicycling, and they consider pedestrian right-of-way as a basic part of human dignity."[14] In the same year, the SMG announced their Seoul Transport Vision 2030 which highlighted the paradigm shifts from privately owned to shared transportation.[15] The city's Vision 2030 included a top line goal to create a "livable Seoul without relying on cars," with specific targets to reduce both car use and transit travel time by 30%.[16] Private sector apps like Kakao have emerged as an option to access taxis, buses, chauffeur services, parking payments, and traffic information. However, smart cards and the transit app developed by the Seoul Metropolitan Government remain the only options for electronic transit ticketing and payment.

3.2 Singapore

Singapore, a densely populated city-state with a small landmass, has recognised and fostered technology innovation to address the unique challenges its residents face. Since establishing its independence in 1965, the Singapore government has adopted a technological, interventionist approach to governance to develop the national economy in a sustainable manner.[17] To achieve sustainable transport, the policies have focused

12 Park, J. Y., & Kim, D. (2013). Korea´s Integrated Fare and Smart Card Ticket System.
13 Ibid.
14 Park, M. (2020). The year of future transportation: An interview, (January 2013), 1–5.
15 Urban Solutions. (2015). Seoul Transportation Vision 2030
16 Ibid.
17 Joo, Yu-min, Teck-boon Tan, and Ming-yee Foo. 2014. "Unpacking Singapore's Latest Mega-Digitalisation Push." In The Smart Nation, 19–37.

on three primary goals: reduce private car use, promote transit and shared mobility, and take a holistic approach to the built environment. Singapore's sustainable mobility plan has focused on promoting transit use and reducing congestion.

From the 1950s to the 1970s, Singapore faced interconnected challenges from largely unregulated markets: "poor traffic management and serious congestion in the city centre, inadequate and inefficient public transport services, poor infrastructure maintenance and lack of governmental plans and enforcements."[18] In 1973, leadership from several ministries formed Singapore's Road Transport Action Committee (RTAC) to lead transportation planning. RTAC introduced Singapore's area licensing scheme (ALS) in 1975, the first congesting pricing program in the world. Under the manual system, drivers needed to buy physical licenses (flat fee) to traverse through designated Restricted Zones. In the late 1990s, Singapore introduced the electronic road pricing (ERP) scheme, a more efficient and flexible system that could adjust the fees by time or location.[19]

The ERP scheme was coupled with high vehicle registration fees to discourage car ownership and use; the growth rate for car ownership steadily declined in the 2010s, leveling off to 0.25% growth in 2015.[20] Notably, average annual Vehicle Kilometers Traveled (VKT) per car declined from 21,000km in 2006 to 16,700km in 2016.[21] The closer residents live to a subway stop, the more likely they are to use public transport as their primary commuting option.[22]

Like Seoul, Singapore invested early in an integrated fare system for transit. In 1990, Singapore set up Transit Link Pte Ltd. to manage the system's first farecard. Then 2002, the Land Transport Authority (LTA), a board within the Ministry of Transport, founded a subsidiary, EZ-Link Pte. Ltd., to create a contactless smart card.[23] The LTA was the primary driver of the operation: "LTA led the entire process of establishing EZ-Link Pte. Ltd., exercising full authority over the project ordering, system design and construction, and its operation and management. It also assumed full responsibility for financing the project. As the superior organisation of EZ-Link Pte. Ltd., LTA has the right to control the operation of EZ-Link and determine smart card ticket policies. These facts show that the smart card ticket project in Singapore is a public project implemented under the full responsibility of the government."[24] By the late 2000s, the EZ-Link card accounted for over 95% of public transit trips in Singapore, providing greater convenience for travellers and data for transport planning.[25]

Singapore has made real-time transit information available via the MyTransport smartphone application. The Singaporean government has also installed on-the-ground cameras and sensors to capture data on real-time traffic flow, equipping more than 300 intersections with advanced surveillance

18 Centre for Liveable Cities, & Land Transport Authority. (2013). Transport: Overcoming Constraints, Sustaining Mobility. Cengage Learning Asia.
19 Ibid.
20 Diao, M. (2019). Towards sustainable urban transport in Singapore: Policy instruments and mobility trends. Transport Policy, 81(February 2018), 320–330.
21 Tan, Christopher. (2017). Drivers no longer going the distance. The Straits Times.
22 Diao, Mi. (2019). "Towards Sustainable Urban Transport in Singapore: Policy Instruments and Mobility Trends." Transport Policy 81 (February 2018): 320–30.
23 Park, J. Y., & Kim, D. (2013). Korea´s Integrated Fare and Smart Card Ticket System.
24 Ibid.
25 Prakasam, Silvester. (2008). "The evolution of e-payments in public transport: Singapore's experience." Japan Railway & Transport Review 50.

cameras to monitor congestion and parking violations.[26] Via an open data platform named DataMall, the Singapore government makes real-time and static datasets on transportation available, including parking availability, bus/train service times, bus passenger volume, and accidents.[27]

In the next era of "People-Centred Transport System" development, LTA has identified three main areas of focus: more connections, better service, and a liveable and inclusive community.[28] This plan considers an ecosystem of infrastructure changes, technological tools, and supporting policies. In 2015, Singapore's Ministry of Transport adopted a new Sustainable Singapore Blueprint, which prioritised increasing active transport infrastructure, additional measures to reduce car ownership, and a transit mode share of 75% for all trips within the city.[29]

The LTA provides a unified approach to managing an evolving transportation system. The LTA not only manages the transit infrastructure and operations, it also issues permits for new private cars and controls the bike share fleet cap. The relationship between EZ-Link and the dominant bike share programme SG Bike demonstrates the challenges of multi-modal integration: co-founder Benjamin Oh notes that "[originally SG Bike] could be unlocked with EZ-Link card (a Singaporean stored value card that can be used for a variety of cashless transactions) but we stopped innovating into that because of the licensing requirements – users now need to scan a QR code to end the trip and you can't do that with a physical card."[30] Further research might examine the technological challenges of integrating bike share directly into the EZ-Link app.

Ridesharing apps such as Grab and Go-jek have aggressively pursued the MaaS vision, positioning themselves as an all-in-one transportation and commerce solution for urban residents. Grab and Go-jek have rapidly expanded from their car and motorbike hailing business in Asian markets to super apps with dozens of services across transport, delivery, and payments.

Grab, one of the earliest ride hailing apps in Asia, was founded in Malaysia in 2012 before relocating its headquarters to Singapore.[31] Grab has integrated not only multimodal journey planning, but also local businesses and services (such as hotels, concert tickets, retail etc.). Grab has partnered with several local taxi services to add more drivers onto the platform, and some of these taxi services are available to be booked on EZ-Link as well. In 2019, Grab introduced their Trip Planner to users in Singapore, which added real time public transit data and recommendations of ride-hailing for the first or last leg of their trip.[32] While Grab facilitates the use of public transit in Singapore, there is no ticketing or booking integration yet.

26 Tan, Belinda, and Yimin Zhou. (2018). Technology and the City: Foundation for a Smart Nation.
27 Land Transport Authority. LTA Data Mall.
28 Chow, Clarice, Jean Chia, and Mina Zhan. (2018). Urban System Studies: Integrating Land Use & Mobility: Supporting Sustainable Growth.
29 Ibid.
30 Zhixin Tan. (2019). "Bike-sharing's turbulent times in Singapore: Q&A with SG Bike's co-founders." KrAsia.
31 The Lufthansa Innovation Hub. (2020). The State of Travel and Mobility Tech in Asia.
32 Grab Press Centre. (2019). Grab Introduces Four New Services in Singapore in its Super App.

3.3 Taipei

For a small, densely populated city, transportation produces serious pollution and congestion challenges.[33] Motorcycles (or scooters) are very popular and are used more than cars as measured by Vehicle-Kilometers Traveled (VKT). Taipei has invested in an e-payment and ticketing ecosystem which covers train, bus, ferry, taxi, cable car, and parking. Additionally, a smart card was introduced in 2002 via a public-private partnership.[34]

Taiwan's Ministry of Transportation and Communications (MTC) recently introduced a long term MaaS strategy in its 3rd National ITS Program (2017-2020).[35] In 2019, the MTC issued a call for proposals for a new MaaS platform for a demonstration project. The platform (named UMAJI, which roughly translates to "Your Best Companion") aims to integrate existing mobile payment methods and offer multimodal trip planning, and provide real time travel information and route suggestions. Interestingly, the small US-based company Metropia was selected as the platform vendor, to be white labeled as Taiwan's MaaS platform. An overview of the project specification claims that Metropia's software will provide enhanced taxi dispatch and pooling capabilities.[36]

Smart cards are widely accessible to transport users in Taiwan, which initially included the metro and bus systems. In a similar pathway as Singapore's EZ-Link systems, a consortium of local government agencies introduced a contactless payment smart card in 2002 called the EasyCard. The EasyCard first integrated the buses and trains through an electronic ticketing system, before adding regional rail, bike share (YouBike), and other modes. In early 2020, the EasyCard Corporation introduced its Easy Wallet, which enabled people to use their smartphone to pay for public transportation, as well as parking fees, water bills, and medical expenses.[37]

When Taipei's public bike share program (YouBike) was integrated into the smart card payment, bike share ridership increased. The smart card data also revealed bike-transit subway behavior; close to 25% of bike trips were to or from transit stations.[38]

33 Wu, Shang Su. (2020). "Smart Taipei City: Understanding Policy Motivations, Approaches and Implementation." Smart Cities in Asia: Governing Development in the Era of Hyper-Connectivity, 61–77.
34 Chang, S K Jason, and D Ph. (2018). "Integrated Transport System Development in Taipei."
35 Chang, S K Jason, Hou Yu Chen, and Hung Chang Chen. (2019). "Mobility as a Service Policy Planning, Deployments and Trials in Taiwan." IATSS Research 43 (4): 210–18.
36 Metropia. (2020). "Integration and Innovation on Shape the Future of Taiwan's Mobility."
37 Chang, Chris. (2018). "Easy Wallet to arrive in Taiwan in January." Taiwan News,
38 Chung, Chih-lin, and Shu-yuan Li. (2019). Intelligent Transport Systems for Everyone's Mobility. Intelligent Transport Systems for Everyone's Mobility. Springer Singapore.

4 Looking Ahead

To deliver quality transportation service to more people, transit agencies have incrementally modernised their system with digital ticketing and payment systems, intermodal connections (such as bus to rail), and intercity connections (for instance, regional transport). In the cities examined in this paper, transit adoption among urban residents is already quite high. As such, cities like Taipei are interested in MaaS as a value add for replacing inter-city car trips via transit integration with shared modes such as car rental, scooters, etc. in addition to exploring intra-city first-mile/last-mile connections.

Digital services (such as payments and mapping for route planning) are essential for transportation service delivery, and payments (credit card companies) and mapping tools (such as Google Maps) are key stakeholders in MaaS collaborations. Transit remains the backbone of sustainable urban transport, and transportation agencies and regulators largely hold the power in selecting which private operators to work with and integrate into agency-managed transit apps.

An effective MaaS programme requires complex cross-sector cooperation between a large number of stakeholders, a robust public transit system, and technical and management capacity for piloting and implementation. For governments, smartphone applications offer two-way transport management – real time information can be pushed to travelers to optimise the transportation systems and aggregate data can help inform transportation planning and policies. The enabling technologies are a means towards ensuring safer, greener, and more equitable transportation access for citizens, with a data-driven approach to enhancing service delivery.

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Kathy Zhang is the founder of "Mobility Futures", a research initiative at Columbia's Center for Sustainable Urban Development established to examine how proactive policies for emerging technology can support a more sustainable and equitable transportation system.

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