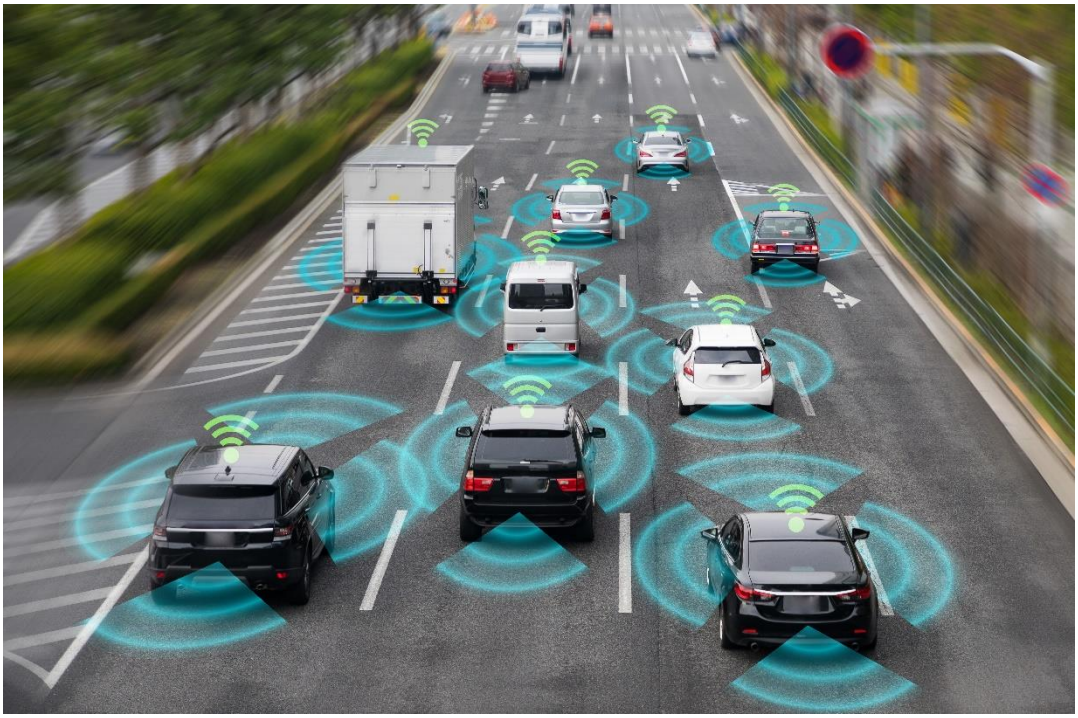
Mobility-as-a-Service (MaaS) Business Model and Its Role in a Smart City



By:

Dr Lee Jian Xing
Principal Consultant
Smart City Solutions

Dr Wu Xian
Senior Executive Engineer
Civil and Environmental Engineering Planning

Jimmy Lee
Principal Consultant
Smart City Solutions

Abstract

In the current digital world, many industries are leveraging on big data to improve their businesses such as providing seamless and convenient experience, consumer centric and improving productivity etc. In transport, big data can play a huge role such as Mobility-as-a-Service (MaaS), Autonomous Vehicle deployment, Electric Vehicle deployment, Next Generation Electronic Road Pricing, etc. A comprehensive MaaS application to help commuters plan their journey seamlessly in terms of time saving, cost saving, or improved comfort level must be created to encourage commuting via public transport. Road congestion is a common problem faced in every city in both developed or developing city. MaaS can help to influence commuters to take public transport or even shift the transport mode if it can

demonstrate value add in their daily commute. Proper MaaS business model should be customised for that market, and it can be treated as one of the initiatives under a Smart City Plan. This paper examines how big data in MaaS can shed light in commuters' travel behaviour and even influence the pattern. We also discuss the different roles undertaken in this ecosystem - such as the government, operators and service providers.

Introduction

MaaS is often seen as a commuter-centric model of transportation which offers on-demand, real-time platform that includes any combination of transport methods such as car, bike sharing and taxis and provides everything for the commuter from travel planning to payments. It tries to break the isolation works from government transport agency, service providers and transport operators and to bring them closer to customers. The philosophy behind MaaS is to direct people to their most appropriate mobility options, in real time, through a single, unified trip planning and payment application (MCMM, 2018). We can imagine how MaaS presents itself as a subscription-based service which allows commuters to choose different transportation modes with a subscription fee or pay-as-you-go (Matt Cole, 2018). In a city that offers different transportation modes, MaaS can help to provide flexibility to commuters for deciding among travel modes, schedules, and price points.

Urbanisation is becoming a reality. A report by Deloitte shows that 66% of the people will stay in urban areas by 2050 (Warwick Goodall et al. 2000) as given in Figure 1. By offering commuters with different transportation mode, it aims to reduce the reliance of private cars and encourage public transport, hoping to reduce congestion, air pollutions and CO2 emission (Transport and Environment, 2018). This potentially helps to move people in a cleaner, cheaper, and faster option.

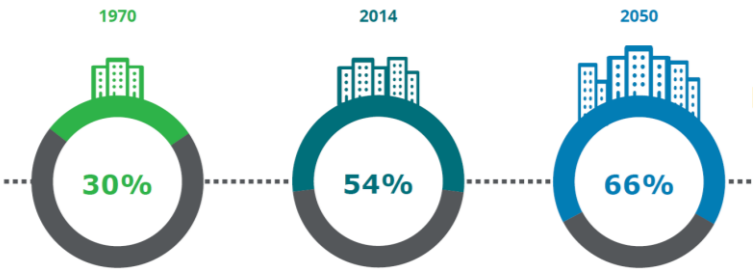


Figure 1. Global urbanization trends: Percent of population living in urban areas

Another sharing by Ernest & Young (EY, 2015) in Figure 2 shows that Europe alone suffers annual congestion loss of US$184 billion in 2014, and it is predicted that there will be 41 megacities with population of more than 10 million people by 2030. If we do not tackle the issue of urban mobility now and without proper planning, the traffic can become stalemate in the near future, which we already see in some of the big ASEAN cities like Bangkok, Manila and Jakarta during the peak periods. Therefore, MaaS could be part of the solution to reverse this trend (Mark Streeting, Emma Edgar, 2017), bearing in mind to integrate between urban, technological and social trends (Matt Cole, 2018). This will influence the manner we manage the city and influence the commuter's manner of travel. A recent impact study by Ramboll on 70,000 Whim mobile application's registered users showed that with comprehensive MaaS

offerings, traffic congestion problem can be solved (Ramboll, 2019). The key findings to the study are highlighted below:

- Whim users make 73% of their trips with public transportation compared to 48% trips made by the average citizen;
- 42% of all Whim users' city bike trips are combined with public transportation;
- Whim users utilised both bicycles and taxis to solve the first-last mile problem;
- Whim customers use a wide range of transportation services, and they are clearly shifting to sustainable mobility patterns, which will have a major impact on city congestion and car dependency.

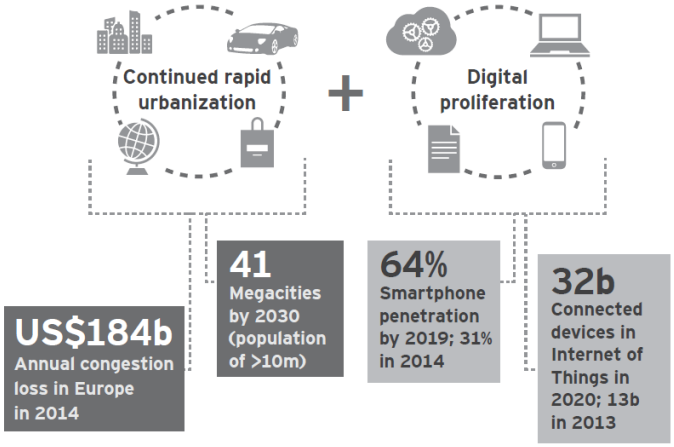


Figure 2. Rapid urbanization and digital proliferation in an urban city

Worldwide Initiatives and Trends

The growth of MaaS can be hampered by operational requirements and revenue. Traditional operators start to realise that their business model will most likely need to change, thus they seek technologies to improve their service level. Additionally, leveraging technology, it hopes to reduce the congestion level in the city. Table 1 below shows the different MaaS initiatives around the world (Warwick Goodall et al. 2000).

Table 1. Illustrative MaaS pilots around the world

Project	Description	Operate By	Scope
Whim app	Through its subscription-based integrated mobility app, Whim, MaaS Global offers users access to a variety of transportation options, from taxis to rental cars, public transport, and bikeshare. The app learns users' preferences and syncs with their calendars to intelligently suggest ways to get to an event.	MaaS Global	Helsinki
UbiGo	This fully integrated mobility service combines public transportation, carsharing, rental car service, taxi service, and a bicycle system—all in one app, all on one invoice, with 24/7 support and bonuses for sustainable choices.	Part of the project Go: smart by Lindholmen Science Park, with partners from industry, academia, and government, co-funded by Vinnova	80 households; approximately 200 users in the city of Gothenburg
Qixxit	With more than 21 service providers, the Qixxit app plans routes according to user needs. It offers carsharing, ridesharing, and bike sharing	Deutsche Bahn	Germany

	options; identifies ideal train connections; and shows all travel possibilities for users to compare and choose from.		
Moovel	Enables users to search, book, and pay for rides with a single app—book and pay for car2go, mytaxi, and Deutsche Bahn in a single experience. Public transportation mobile payments are available in Stuttgart and Hamburg.	Daimler	Germany; also testing in Boston, Portland, and Helsinki
Beeline	In Singapore's first marketplace for crowdsourced bus services, users can book a seat on buses listed by private bus operators and track their location. They can also suggest new routes since new routes are activated by community demand.	Government agencies Infocomm Development Authority and Land Transport Authority in partnership with transportation operators, academia, and the private sector	Commuters in Singapore
SMILE app	The idea behind SMILE was to offer a wide range of different transportation options with the following functions: information, booking, payment, usage, and billing. A standardized interface enables all mobility partners to link their technical systems via specific adaptors to provide all their data, including the ticketing.	The SMILE project was initiated by Wiener Stadtwerke in cooperation with Wiener Linien (Vienna's public transport provider), Austrian Federal Railways, and private carsharing, taxi, and bike sharing service providers.	1,000 pilot participants in Vienna
Bridj	Bridj is an on-demand commuter shuttle service with a mobile phone application that allows passengers to ride a shuttle between home and work during commuting hours. Using a fleet of flexible vehicles, Bridj optimizes pick-ups, drop-offs, and routing based on demand, meaning a 40–60 percent more efficient trip than traditional transit.	Bridj Inc.	Commuters in Boston, Kansas City, and Washington, DC
Communauto/ Bixi	In Quebec, some municipal transport authorities have offered mobility packages that include bike sharing by BIXI and carsharing provided by Communauto. For example, a user can save on the regular price of a public transport pass and bike sharing by subscribing to the BIXI-AUTO-BUS package.	Communauto	Cities in Quebec, Canada

Frost & Sullivan (Martyn Briggs, 2015) predicts the potential of future integrated mobility will leverage technology to provide door-to-door, multi-modal travel encompassing pre-trip, in-trip and post-trip services to improve journey experience to the commuters as illustrated in Figure 3.

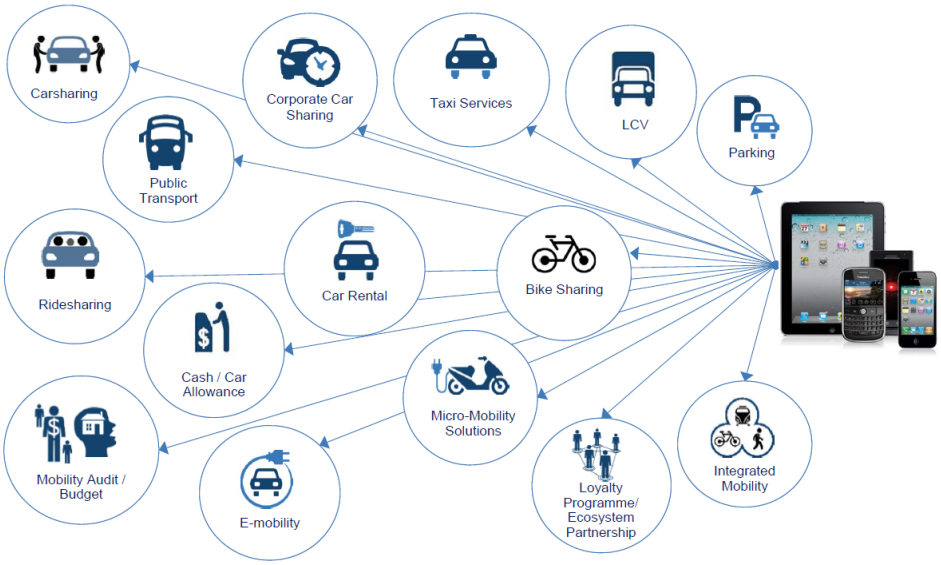


Figure 3. Definition and potential of integrated mobility

A survey conducted by UCL MaaSLab (Maria, 2018) in London shows that 62% of the interviewees prefer a MaaS platform that offers more transportation options and they will likely use MaaS as shown by Figure 4 and 5 below respectively.

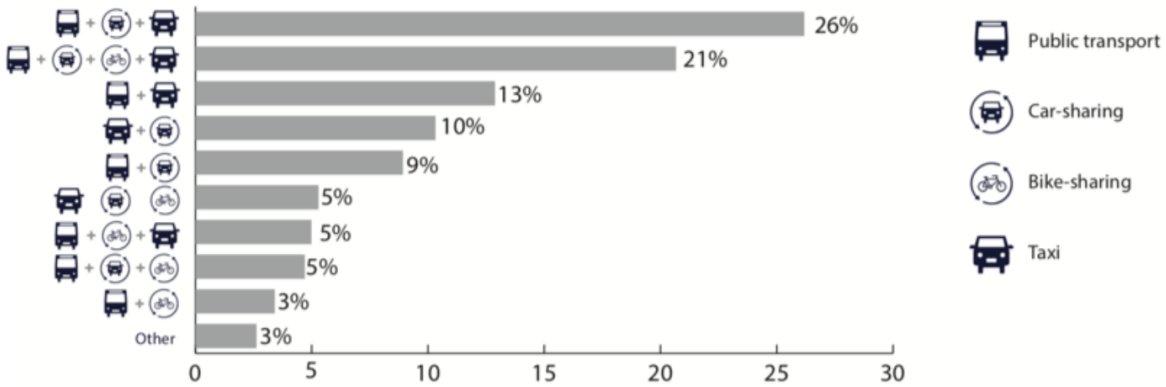


Figure 4. Transport mode combinations in the preferred MaaS plans

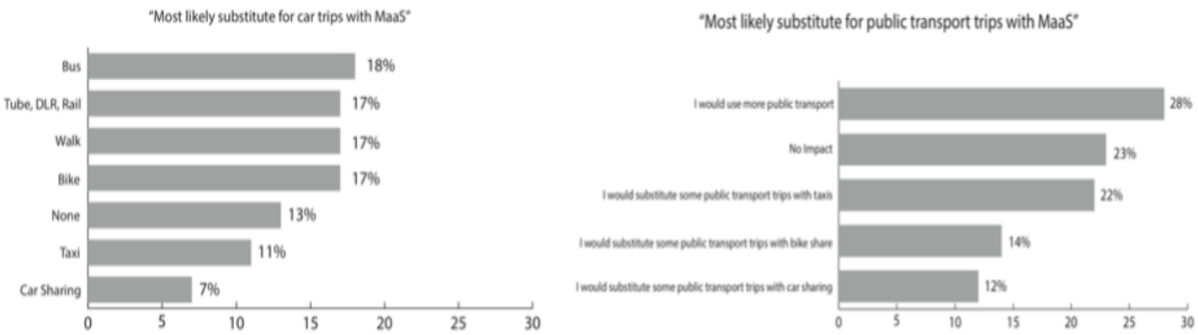


Figure 5. MaaS preference adoption rate

A research conducted by Arup (Ryan Falconer et al., 2018) in Figure 6 tries to match the type of MaaS solutions with the types of trips as shown below. Demand responsive transit (or

microtransit) and ride-sharing can help commuters to travel more seamlessly and even bring services such as medical services closer to them.

Trip Types		MaaS service solutions
First-last mile connections	Facilitating trips between residences and transit stations in suburban areas is a common concern for transit agencies in North America, and those operating in the GTHA are no exception. Low development densities around stations lead to relatively low levels of conventional feeder (usually bus-based) transit service and dependence on park-and-ride and kiss-and-ride for station access. Park-and-rides consume land and add capital and operational costs to the transit system. Traditionally, taxis have operated at a price point that exceeds most consumers' willingness or ability to pay.	Ride-sharing, ride-hailing and microtransit
Suburban-to-suburban trips	Trips between low-density locations or low-density origins and suburban centres are difficult for traditional transit to service effectively. Short operating hours, circuitous routes and long headways contribute to dependence on driving, with the result that those without cars are negatively affected by low levels of access and personal mobility. Again, taxis have tended to operate at a price point that exceeds most consumers' willingness or ability to pay. In the GTHA, providing alternatives to the suburban-to-suburban single-occupancy-vehicle commute offers one of the single largest opportunities to effect positive environmental impacts in this sector.	Ride-sharing, ride-hailing and microtransit
Airport trips	Airports are located typically well outside downtowns and therefore do not always have access to significant transit hubs. Many air passengers have to transfer multiple times to access the airport using traditional transit services. Taxis have often been the default and only realistic mode choice for many consumers to access the airport. Alternatively, consumers may drive to the airport and park their vehicles in car parks provided or arrange personal drop-offs. The vehicular congestion that can manifest itself is compounded by employee commute trips. In the GTHA, the Pearson Airport Employment Zone is one of the densest employment areas in the country and is significantly underserved by higher order transit.	Ride-sharing, ride-hailing and microtransit
Hospitality and events trips	If a consumer is socializing and wishes to drink alcohol, and/or is undertaking extraordinary travel for a special event like a concert or sports game, they may want or be compelled to avoid driving or riding a bicycle. They may also be less willing or able to use conventional transit. Until recently, traditional taxis may have been the only reasonable mode choice.	Ride-sharing, ride-hailing and microtransit
Off-peak trips/ shift workers	Trips outside peak periods — especially later in the evening, overnight, very early or on weekends — must be conducted when there is lower (if any) availability of conventional transit services, limiting mode choice in many cases to driving or traditional taxis. These trips are often centred on low-density industry or manufacturing zones, which further compounds the availability of options.	Ride-sharing, ride-hailing and microtransit
Downtown trips	There can be many conventional mode choices for trips originating in or conducted around a downtown environment. Nevertheless, the availability of MaaS service options can encourage residents of downtowns to avoid car ownership and even ownership of personal bicycles, and can act as a substitute for walking and conventional transit trips.	Ride-sharing, ride-hailing, microtransit, car-sharing (one- and two-way), bicycle-sharing
Health care/ health service delivery	Traditional delivery of health care services can be costly and does not always well serve the needs of the mobility impaired, particularly if multiple jurisdictions having different agency and mandates are involved in the delivery of the trip. Health care service providers are actively seeking opportunities to facilitate and optimize the delivery of mobility for their clients, in a manner that maintains (or enhances) the level of community connection and care already being provided.	Ride-sharing, ride-hailing and microtransit

Figure 6. Trip types of the trip market with greatest potential for realized value

In summary, there are many advantages that can be realised through MaaS adoption such as:

- Improve quality and convenience of travel;
- Reduce overall waiting and journey times;

- Allow better monitoring, management and planning of mobility services;
- Reduce the cost of mobility with different varieties of transport modes; and
- Potential new revenue sources.

However, there could be challenges if not managed properly, such as:
- Cannibalising public transport and reduction in its revenue;
- Causing road congestion;
- Commuters privacy and data protection.

Proper study on the roles of MaaS in different types of city development should be conducted, which shall be addressed in Section 1. The roles of the different stakeholders will be analysed in Section 2, together with an appropriate fare structure and how data analytics play a part in enhancing MaaS. Finally, the paper concludes in Section 3 with a framework and strategy for a Smart City Plan to embrace MaaS as part of its smart initiatives under urban mobility.

1. Role of Mobility-as-a-Service (MaaS) in a City

Intracity

For MaaS to work effectively within the city, it must be able to integrate all the different transportation modes onto a single platform with cashless payment. This will provide convenience to the commuters where the software plans the best transit choice at that time. From the regulator viewpoint, MaaS can serve as an alternative for low cost recovery public transport route. Instead of having to incur high CAPEX and OPEX and continue operating low ridership route with fixed fleet size, MaaS potentially would deliver a more personal service at a fraction of the cost through matching with various transport mode or on-demand services.

Intercity

For intercity travel, there are many transportation modes and integration amongst them on a single platform. For example, commuters in Europe can use MaaS platform to book and travel with different railway operators. Amtrak and Greyhound have a common ticketing system for certain routes, allowing commuters to transfer with the same ticket.

In some big cities, private cars are still the preferred modes in the regional or suburban areas. However, MaaS can help to act as agents connecting people living on the outskirts of the city to the main transportation corridors. MaaS can also be particularly helpful in small urban and rural communities, which lack the varied menu of options compared to urban areas. If MaaS proves to be popular, it can benefit not only to the commuters but also to the public transit operator by driving increases in revenues and helping to redirect funding and investment back to core transit services. A study by AARP Public Policy Institute (Jana Lynott, 2018) in USA shows that a trend that rural populations are eager to accept the shifting of transportation landscape through technology, and between 2007 to 2015, the ridership on rural public transport increased by 8% despite declining population. Therefore, a combination of on-demand or ridesharing services will be welcoming to the rural or suburban population.

Smart City

MaaS has the potential to add on more different transport modes such as car rental, or even flight or ferry services, preferably with auto currency conversion. However, this will require proper regulation amongst the countries. European cities are the fore-runners for such an integrated intercity transportation. The next implementer can be amongst the ASEAN region. Nevertheless, a scheduled travel journey with a single price package is the way to go. With more people moving into cities, such problems will almost certainly only worsen without a unified transportation solution.

MaaS could also potentially free up valuable real estate especially in urban areas because parking lots are occupying city spaces. A study by Cubic (Matt Cole, 2018) shows that an average parking space takes up 300 square feet (including alleys between parking lot, lost space for vehicles to manoeuvre) which is equivalent to a housing area for 10 bicycles, that is potentially addition of 5 consumers visiting the building. By reducing car park lots, these spaces can be converted for recreational or tenanted purposes and reducing carbon footprint.

However, to make the cities ready, network infrastructure such as the interconnectivity of telecommunication network, high speed public WiFi coverage etc must be properly planned and provisioned.

Congestion

MaaS, if not managed properly, can create problems such as congestion on the road. For example, commuters may book and subsequently cancel if they are able to street hail, and these empty trips will add to more vehicles on the road. Secondly, if the price is too attractive in addition to the convenience it brings to commuters, we can see a surge in the booking, resulting more vehicles on the road. In normal situation, the non-revenue return trips after dropping off commuters will add to the number of vehicles build up in the area, for example during the morning peak in the CBD region.

Arup also conducted a similar study in New York showing there is a shift of ridership from public transport, walking and cycling to ride-hailing, adding to congestion, while public transport trips have declined (Ryan Falconer et al., 2018). The Southeastern Pennsylvania Transportation Authority (SEPTA) has also reported reduction in public transport ridership since ride-hailing became available. Although there is no evidence of direct causation, but initial findings suggest that the price point and increasing convenience of services such as Uber has led to mode substitution.

A study by Bruce (Bruce Schaller, 2018) stated that ride services such as Uber and Lyft transported 1.90 billion passengers in 2016 to 2.61 billion passengers in 2017 which is a significant 37% increase in highly concentrated, large, densely-populated metro areas in USA where most of the passengers are young, affluent and well-educated. This equates to about 60% shift of ridership from public transportation, walked or biked. For any private car drivers

who switched to taking ride services, it contributes to 2.8 new service rides on the road. Therefore, targeted policy such as better incentives for shared services, ensuring frequent and reliable bus and rail service can help to influence some modal shift back to public transportation and lesser vehicle trips on the road.

With new technology such as Autonomous Vehicle (AV), congestion probably can be reduced because the vehicles can be parked and travelled only when a call is received. This is because there is no driver and hence no pressure for continuously driving to find customer. Additionally, proper prediction of congestion and charging mechanism for private road user such as through the Next Generation Electronics Road Pricing potentially can shift the travel mode towards public transport. However, if not properly managed, when technology companies and automakers are able to provide attractive door-to-door ride services, and weaning people off their personal vehicles and combining the convenience of ride services, this may result in more trips on the road.

2. Different Business Model for Mobility-as-a-Service (MaaS)

The European Union has created the MaaS Alliance which a Public-Private-Partnership (PPP) model that share information among the players in the transport value chain and integrates all transport mode into a single platform. This collaborative ecosystem helps to spur further developments in the MaaS market. Another example is MaaS Global, when it was the first MaaS operator in 2016 that introduced Whim app in Helsinki, and with the support of transportation laws that helps to regulate an open market for mobility services. With such a collaborative ecosystem, the roles of the different stakeholders must be clearly defined.

<u>The Transportation Value Chain - Their Needs and Roles</u>

a. Regulator

A regulator should define the vision and set proper governance such as limiting the number of licences to avoid crowding the market. For pricing matter, it is best to leave it to the ecosystem to determine. To facilitate development of MaaS market, regulator should also encourage investment in programmes for innovations.

Regulators should be able to gain access to certain data because it can influence the development of the multi-modal environment, decides how public assets such as roads, walkways and parking lots are used, or what is the service level performance from the service provider through their real Origin-Destination (OD) information communicated to the commuters. The data gained from the MaaS platform can be leveraged to plan for our city's futures.

Regulator should ensure equity provision of transportation for all homographic such as low-income, and underserved populations should be taken into consideration and work with the different stakeholders. On a wider public interest, regulators protect commuters who may have fallen behind by the rapid growth of transportation services.

Finally, a balance of regulations should be checked frequently. Too many regulations may hamper the advancement of the MaaS market, while too few regulations may cause the public interest not being served, with limited say in shaping the future travel behaviour of the commuters.

b. MaaS Service Provider

An MaaS service provider should integrate different transport options into their platform to offer the best mode of travel for commuters in terms of time saving, cost saving, comfort or even customised preferences. A single app is needed to coordinate all access to public and active mobility modes, using a single user account where the commuter can pay for his entire journey. This can offer an opportunity to encourage mode shift from private vehicle ownership to public transport. As part of innovation, MaaS should be flexible to giving incentives such as allowing drivers to earn credits when they wish to take public transport for that particular day.

Recently, Grab announced a Beta version for an on-demand pet-friendly transportation service, GrabPet, allowing commuters to book a transport service to bring their pets around Singapore. Another new initiative, Zipster app in Beta version, announced by mobilityX, a start-up backed by transport operator SMRT, as well as the general trading arm of carmaker Toyota, Toyota Tsusho, allows commuters to plan, book and pay for their journeys across a variety of transport modes in Singapore. mobilityX also partnered with AXA to insure commuters for their trips. In the longer term, mobilityX is also looking at offering subscription packages that would allow travel across a variety of transport modes at a flat fee.

Millennials are fuelling a new transportation paradigm with their love for mobile apps, preference for convenience and spontaneity, comfort with the sharing economy, and expectation of connectivity anywhere at any time. Urbanization and the aging society also increase the demand for transportation alternatives to driving. For inclusiveness, MaaS service provider must include these services to commuter without smart devices or who are digitally illiterate. One solution can be a dedicated dial-in number with pin for this group of people to book a transit service. The success of every MaaS player is dependent on the nation having a robust public transportation system in communities of all sizes.

MaaS service providers should allow opportunities for experimentation to continue improving the platform. Open Application Programming Interfaces (APIs) can allow new mobility or other commuter centric services to integrate with existing mobility services to allow and improve multimodal trip planning, and other experiences that form part of a daily commuters. In EU, Finland Transport Code (2018) requires an open API for all public and private service providers so that all can be integrated into one seamless travel chain, paid by mobile system, and all intercity transport modes can be integrated into one holistic system. Tying back to ASEAN, given the proximity of ASEAN countries, it is beneficial to follow EU's initiative to develop such a common platform.

Most importantly, MaaS service provider must ensure the safety of the data, as well as the security against potential data leaks. Because individual service providers are not likely to

share their data, having a third party involved can remove some of the barriers to cooperation. Therefore, MaaS service provider must have proper security governance to manage the data exchange between the different providers, API gateways, data analytic for usage, demand, supply, planning, payment and reporting.

c. Public Transport Operator

Public transport operator should focus on operating and maintaining good public transport service to the public. The awarded contract to run such services should come from the regulator with attached KPIs, which should be monitored by the MaaS platform and in turn, generates monthly report for the regulator. Public transport operator will provide a travel fee to the commuter through the MaaS platform.

Public transport operators who neither take notice, nor show interest can potentially risk losing relevancy in the fast-moving transportation market. They may also lose out to private companies who tend to have more resources or aggressive approach to innovation.

d. Private Transport Operator

Private transport operator can also take part in the ecosystem through offering a differentiated service compared to the public transport operator. These types of service should be more inclusive for the commuters such as door-to-door, friendly to elderly, people with disadvantaged mobility or families with children. For example, hospital or healthcare institution can partner with MaaS service provider to provide transport service for people with disability or elderly on a regular basis at an affordable price compared to taxi. This initiative is not new because Denmark's FlexDanmark portal integrates more than 550 private and public providers to despatch the correct vehicles to the commuter's door step, through their call centre be it on demand responsive or on schedule. Likewise, in the States, Lyft and GoGoGrandparent allows an elderly to book a trip via phone call. Elderly in hospitals or senior independent living centers can request rides via Lyft and Uber platform with subsidised fare.

e. Other Service Providers

Although the name of MaaS implied related to transport, other services can also be incorporated such as drive through food station, petrol pumping, hotel booking, etc - all relating to a commuter's level of travelling. This will create a total inclusive commuting experience from origin to destination. Advertisement can also be published on the MaaS platform available for commuters while they are waiting for pickup. This can also serve as a revenue channel for the MaaS service provider.

f. Infrastructure Providers

MaaS is powered by the growth of smartphones and to work effectively, citywide telecommunication network connectivity backbone must be provisioned during the master planning stage as part of a Smart City initiative. Otherwise it can be onerous and costly to

integrate the physical with digital world in the future and hamper the growth of digitisation for the transport community.

g. Commuters

Currently, commuters have little choice on their transport modes for reasons such as convenience, fare, time saving, etc. Therefore, for MaaS to be successful, it must provide commuters the freedom to choose from the different travel modes and facilitate origin-destination journey.

Next is commuter perspective. People want the most straightforward, seamless way to reach their destinations, and want to be able to choose the option they perceive can achieve the right balance of convenience and cost. This is why in cities with strong transit systems, people still elect to drive, since their view is that waiting for a transit vehicle to arrive is a burden, and the cost of driving (whether accurately perceived by them or not) is a price they are willing to pay. Another classic example of this hurdle comes with older generation, certain family status or business demand who are reluctant to stop driving, as they often view cars as a representation of their status. Therefore, through education or actual travel pattern, the results can better inform the commuters on the advantage of taking public transport.

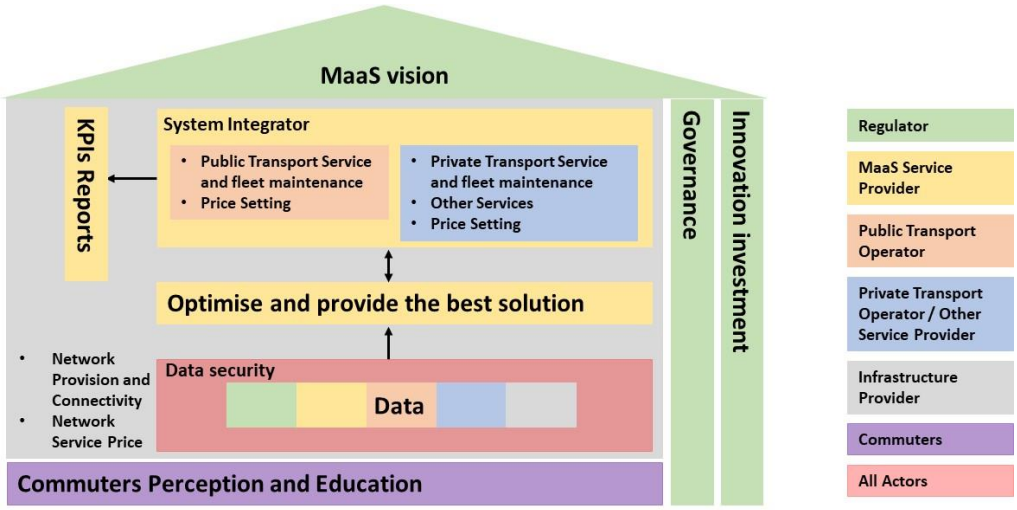


Figure 7. Summary of actors' role in the MaaS ecosystem

Figure 7 above summaries the roles of the different actors in the MaaS ecosystem.

<u>Fare Structure</u>

Today, the most common payment mode is pay-as-you-go, with individual stand-alone single mode fare and pricing structure. Some has evolved into loyalty-based incentives, with fare capped, demand led dynamic pricing such as Uber and Grab. Moving forward, innovative payment mode can take on monthly subscription or even yearly pass. Subscription based model allows different operators to offer their services in bulk by allowing them to be purchased as a package by the commuters, intercity integrated multimodal pricing, and even bundled products with other consumer-based offerings. In a more innovative fashion, it can incentivise

drivers who wish to take public transport for the day, and offer rebates or vouchers for purchasing grocery at supermarket, or dynamic fare setting during peak and non-peak periods.

As MaaS evolves, there must be a common and transparent structure of revenue split (e.g: coordination fee, clearing fee, promotion, subsidy etc) made known to all service providers, operators and to a certain extend to the regulator. This is an agreement that should develop at the beginning of their relationship to facilitate growth and innovation, consistency and reliability as the system develops and more providers join. It will be important for all entities to agree on a cost structure that supports the service.

There must also have a balance of providing affordable service to the commuters compared to revenue. In many cities, transit is heavily subsidized by various levels of local and central government, to make it affordable to the disadvantaged and low-income communities. Commercial mobility operators do not qualify for subsidies nor care little about the impact of fares on ridership. In fact, whenever there is a fare increase, they make more profit. Another example is whether surge pricing is fair by taking advantage of increased demand and charge premium prices during constrained supply.

Ultimately, the cost of taking public transport must outweigh the cost of car ownership, and with better access to other transit means, their mobility level can be increased. For convenience, commuters can pay their ticket via a single platform, without navigating through various browser, otherwise the MaaS platform becomes unattractive.

Data Analytics

Without the engine behind making sense of the incoming data, MaaS evolvement can be stalemate. Understanding travel demand is important but predicting travel demand is even more crucial. With big data analytics capability, it can have better balance of supply to meet demand during peak periods, or areas where there are events happening etc. In addition, predicted congestion on the road, capacity utilisation rate for trains or buses, or nearby events' information can influence commuters travel behaviour.

First, establishment of background traffic through simulation is important to build the base. Subsequently, commuter travel pattern with infrastructure development can be incorporated to give a micro level understanding of the supply and demand spread. More sophistication inputs such as WiFi signal, events information, buses or trains capacity utilisation and roadside congestion sensors provide real time information to influence travel behaviour. As part of a Smart City, and through data analytics, it should also be able to analyse the travel patterns of individual. It can even access the calendars of the individual or connected to Smart Home application to offer the suitable transport mode or subscription according to the schedule.

Looking into the crystal ball, MaaS offerings will likely incorporate with AV deployment. This is when data analytics plays an even important role because the request from the type of commuters (e.g: elderly, people with disability) needs to reach the AV before it arrives at the Pick-Up-Drop-Off (PUDO) points. This will influence how the AV responds to the hailing request and picking up the correct customer.

However, there is a chance that through data analytics, MaaS tends to target specific demographics such as the affluent and digitally savvy commuters and leave out low income communities. Therefore, proper governance needs to be established to ensure that the interest of the public is well served, to avoid MaaS damaging the patterns of social exclusion in poorer and more isolated communities.

Another key consideration is data privacy because any leak in data can break the system. Regulator should consider establishing clear and fair rules for the management of data and information flow. The ecosystem must ensure transparency to the public that who holds the data, how it is used and protected, what data is shared to whom and for what purpose, and who is accountable. However, the details of how the data should be governed is beyond the scope of this paper.

3. Conclusion and Next Steps

The paper has examined the trend and initiatives around the world and discussed the roles of MaaS within the intracity, across inter-cities and towards a Smart City. For this to happen, the different roles of the stakeholders must be mapped out clearly, paying attention to different fare structures. However, an important consideration is the value-added services that can be realised through data analytics but without compromising the data security and safety.

<u>Framework and Strategy</u>

Stakeholders analysis through workshop is a continuous process, especially with the different stakeholders as described in Section 2 above. From the result of the stakeholders' engagement, we need to determine the appropriate initiatives and strategy for achieving the vision. A process flow is illustrated in Figure 8 below. But do note that vision can be evolved over time, as the city prospers, and the commuter needs become more demanding. Therefore, it is proposed to re-visit the vision regularly such as every 5 years.

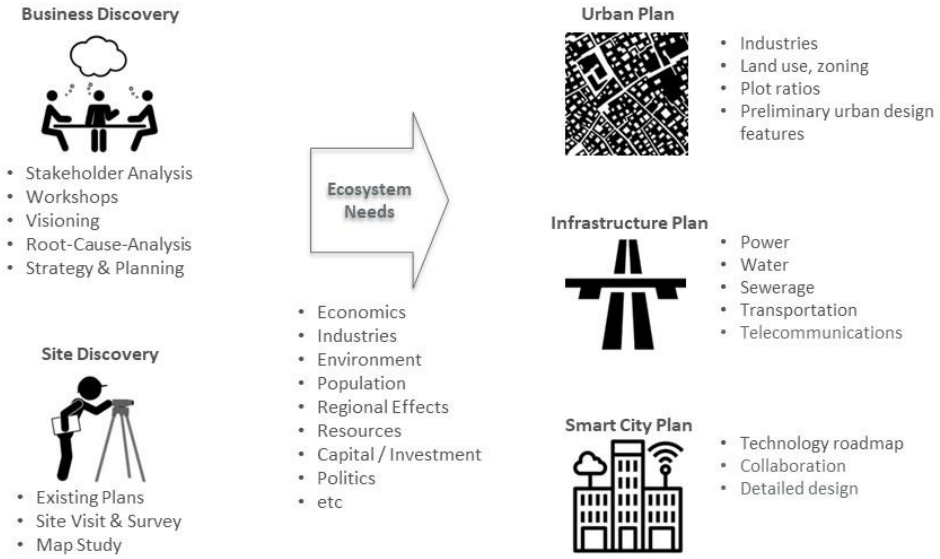


Figure 8. Process flow from visioning to plans

An example of the different strategic themes and enablers for a Smart City plan integrating with mobility is illustrated in Figure 9. After identifying the various strategic themes and enablers, their respective timeline, together with the system, organisation or human interfaces will be mapped out to align with the city development. In tandem, the KPIs, roles of different stakeholders and the pros and cons will be identified.

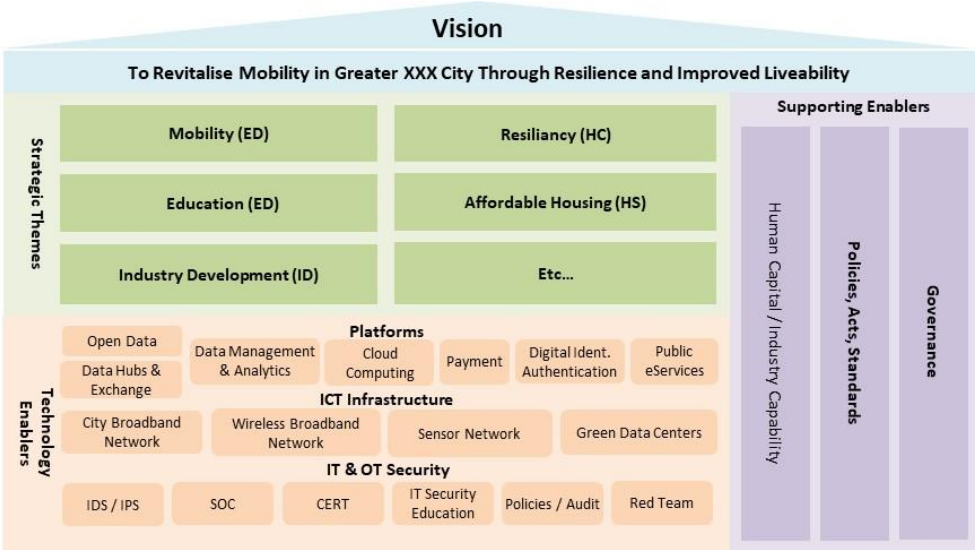


Figure 9. Illustration of a Smart City plan

What was described in Figure 8 is typically called a top-down hypothesis, whereas a strategy alignment where the initiatives identified will influence the People, Process, Technology and Organisation. With the introduction of data analytics, the strategy will be validated with the available data. Figure 10 shows a data analytics process which we normally classified as bottom-up discovery. The process will start with identifying the business objectives. From the available data, we will do a trend analysis and build the model. With new data input, the model will be improved when the output is compared to historical trend. Finally, root cause analysis will be performed and the solution proposed must be aligned to the overall business goals.

In the context of MaaS, the business objectives should be consulted with the various stakeholders identified in Section 2 (i.e: Regulator, MaaS Service Provider, Public Transport Operator, Private Transport Operator, Other Service Providers and Commuters). Historical data can be drawn from the ezlink card, land planning data or household survey. Certain trends can be plotted such as OD pairs within a geofenced across different periods within a day, a week and even a year. With new OD information, trends can be validated and even updated as the population, infrastructure or development change. Any new products, services or remedy that are going to be implemented will eventually need to be aligned to the business goals identified during the initial stakeholder analysis. However, it should be noted that stakeholder analysis should be conducted on a regularly basis, for example, every 5 years to be relevant to the demographic and development change.

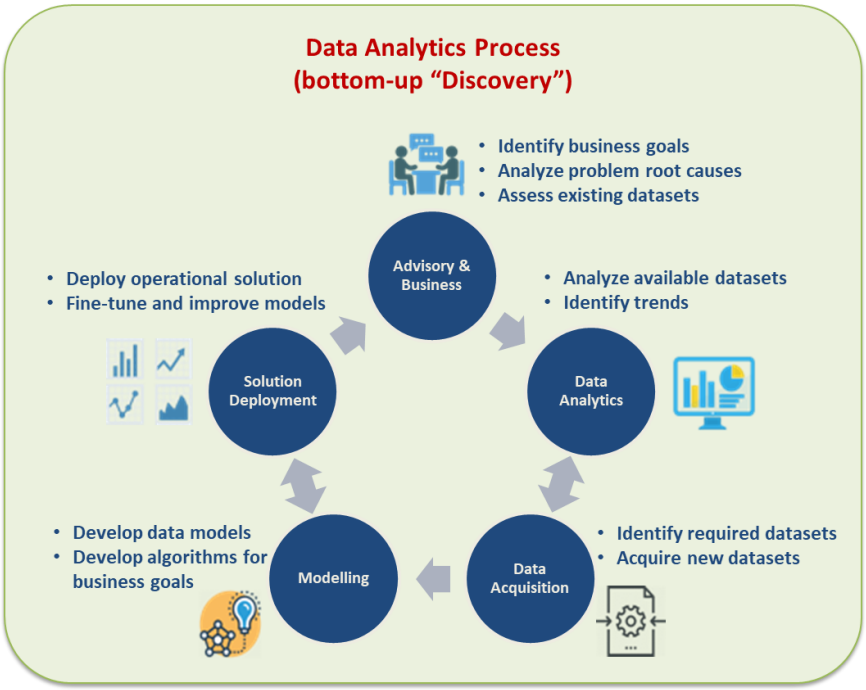


Figure 10. An illustration of a data analytics process

Connect with Us

Dr Lee Jian Xing
Email: jianxing.lee@surbanajurong.com

Dr Wu Xian
Email: wuxian@surbanajurong.com

Jimmy Lee
Email: jimmy.leeyw@surbanajurong.com

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