QIC

RED PAPER

Mobility-as-a-service

The coming transportation revolution

June 2018

Each generation appears to think that changes experienced in their time are the most dramatic in history. Everything is said to be "bigger, faster, best/worst, unprecedented" and on it goes. Until the next generation says the same thing.

That said, there are times of genuinely profound change and transportation is arguably experiencing its most transformative age since the automobile's introduction.[1] Traditional concepts such as "mass transport," or weary language associated with daily struggles like "parking is always a nightmare," "I'm always having to rush to catch the train/bus" are being examined through a new lens thanks to the promise of "Mobility-as-a-service (MaaS)."

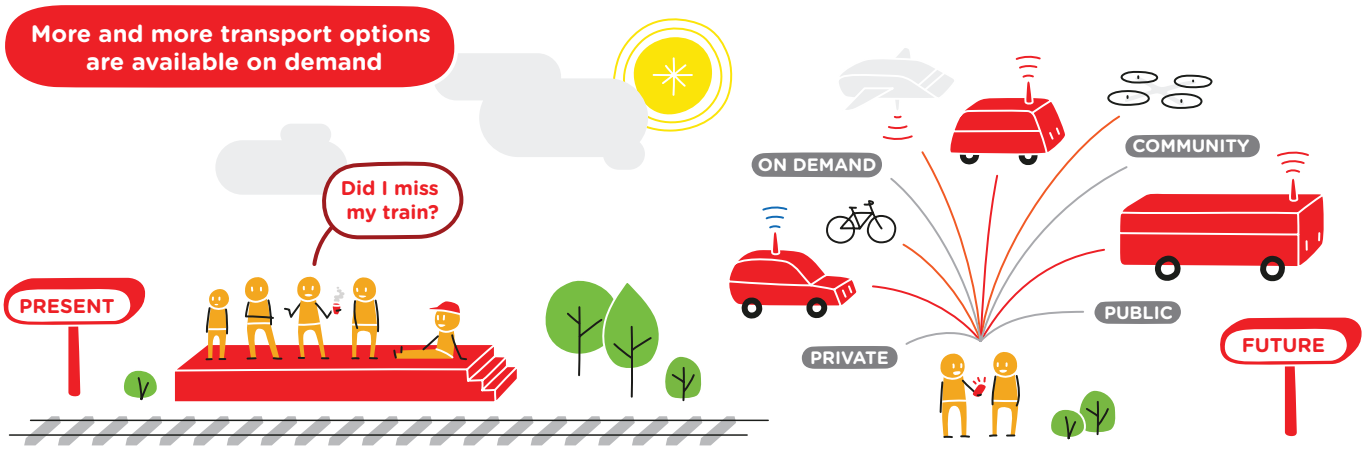
The MaaS Alliance, a public-private partnership created by the European Union and aimed at laying the foundations for a common approach to MaaS, describes MaaS as:

"the integration of various forms of transport … into a single mobility service accessible on demand," which provides "an alternative to the use of the private car that may be as convenient, more sustainable, help to reduce congestion and constraints in transport capacity, and can be even cheaper."[2]

Strip away the bureaucratic tone and MaaS distils down to just a few things.

Essentially, MaaS is about personalising and making more intimate people's journeys from where they are, to where they want to go to, with one account/fare to cover all types of mobility — automobiles (taxis, shared-riding, ride-hailing), bicycles, buses, rail and ferry (**Figure 1**).

Figure 1: Current reality vs future state



Source: Transport for NSW, 2017. *Megatrends*- Future Transport

Like so much else in the contemporary world, mobile devices are the great force behind MaaS.

Thanks to mobile technology, the world is now a place where consumer demand, rather than any other influence, determines the delivery of services; where usage trumps possession; access rather than ownership is king, and where consumers' immediate needs can be satisfied with the tap of an app.[3]

Consumers can order food to their homes by tapping an app (Uber Eats). Music can be downloaded (iTunes). Rides can be hailed (Uber/Lyft). Movies streamed (Netflix).

Transport infrastructure, traditionally regarded as essential services, are not immune to these changes. A quantitative online study of 1,000 Australians conducted by Newgate Research as part of the University of Sydney's Better Infrastructure Initiative

found that only 34 per cent and 36 per cent of respondents respectively viewed operators of non-tolled main roads and tolled motorways as customer-focused.[4]

Conversely, 87 per cent of respondents characterised ride-sharing companies as customer-focused. These results underscore the growing pressure on traditional transport assets to meet more personalised customer needs based on convenience, comfort, quality, accessibility, cost, and sustainability.[5]

If transport stakeholders, particularly investors, are going to meet these growing customer expectations then established infrastructure assets must be transformed into dynamic transport networks which are suitable for MaaS platforms, guided by a clear understanding of user behaviours and customer expectations.

Of course, it's not just mobile devices and payment systems that are animating MaaS. Ceaseless urbanisation as well as the ubiquity of the car are also powerful influences. See *Addressing congestion; enriching quality of life* for more on this.

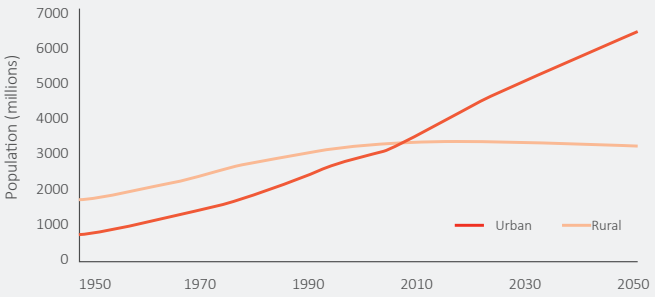
ADDRESSING CONGESTION; ENRICHING QUALITY-OF-LIFE

Changes happening in the world's cities are setting the scene for MaaS.

Rapid urbanisation is both a fact and a megatrend (**Figure 2**). More people are living in cities and their surrounding areas today than ever before. It's estimated that every week, three million more people move to cities around the world.[6]

By 2050, urban residents' numbers are expected to grow by 2.5 billion, which means that city dwellers will account for around two-thirds of the world's population.[7] This rapid growth of the world's urban spaces has profound implications for city life.

Figure 2: The urbanisation megatrend is also driving MaaS
Urban and rural population of the world: 1950-2050



Source: United Nations, 2014. *World Urbanization Prospects: The 2014 Revision*. UN DESA/Population Division

Congestion, particularly at peak travel times, has reached an all-time high. In the United States, bumper-to-bumper traffic costs the economy US$72 billion each year in lost time and wasted fuel. In Los Angeles, alone, drivers are spending 102 hours a year stuck in traffic jams.[8]

Of course, congestion is not a US-only story. Residents in any number of the world's major cities can recount similar, if not worse miseries.

Ironically, the car — long a symbol of freedom and mobility — has become a victim of its own success as traffic congestion limits and undermines mobility across the world's metropolitan areas, imposing huge costs on individuals, economies and society.

The basic problem confronting transportation planners is that adding new infrastructure to relieve congestion is a notoriously slow and costly process. It's what legendary road builder Robert Moses learned in New York City in the 1930s; every time the city opened a new parkway, it was overrun with traffic jams.[9]

Approaches like more flexible work patterns, valuable as they are, can only help at the margins. Clearly, traditional responses centred on building new rail lines and roads, by themselves, are not the solution.

Maintaining, let alone improving current quality of life is an impetus for MaaS. To be clear, successfully tackling congestion, and making it possible for people to move easily and comfortably from place-to-place is not about pitting cars (and roads) against mass transport such as trains (and railway lines).

Zero-sum thinking will entrench current stresses, not transcend them. MaaS represents a transformative vision, a step-change that would integrate public and private infrastructure.

CURRENT REALITY: TRAILBLAZING CITIES

It's recognised that residents living close to the centres of the world's major cities are generally quite well served by existing transport options. However, it's a different tale for the many millions in outer metropolitan areas.

For them, getting to and from work, indeed getting from place-to-place, involves navigating different modes of transport, each with their separate timetables, and payment systems and accounts. Optimising the "first mile" and "last mile" of journeys is especially challenging owing to inefficiencies stemming from poor modal design and integration.

Initiatives, such as on-demand mini-bus services have been trialled in some locations to address this with mixed success. Helsinki's government-run on-demand bus service, Kutsuplus, for instance, folded after two years due to lack of scale and flexibility. [10]

MaaS aspires to address every component of the travel journey as part of a truly customer-centric approach to moving people (**Figure 3**). Effortless, seamless transport choices at the service of people, rather than people having to fit their lives and plans around transport availability is the MaaS ideal.

Figure 3: Mobility is likely to change by type of city

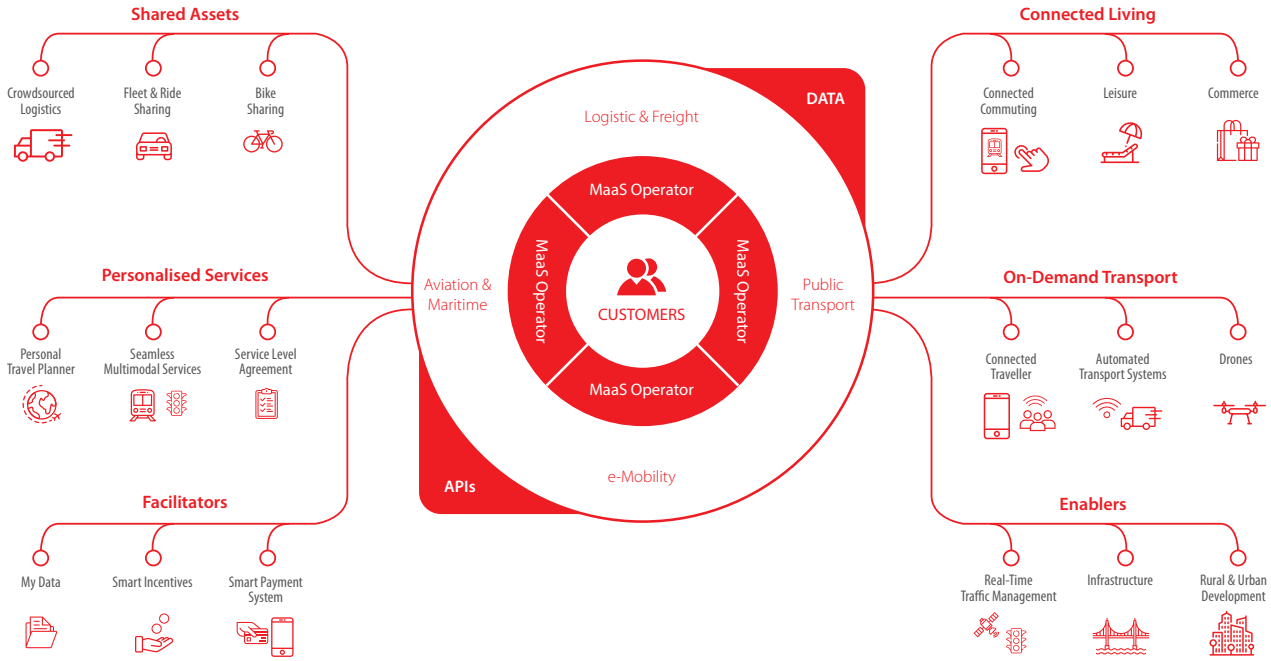
Source: McKinsey & Company

MaaS would offer users a centralised, digital platform (**Figure 4, on next page**) to register, plan, book, e-ticket, and pay for an entire chain of public and private, multimodal service offerings, think Google Maps, Trip Advisor, Expedia and PayPal all rolled into one application. [11]

Using data collected on network status, consumer travel patterns and preferences across the transport system, MaaS platforms would optimise the network for operators by calibrating supply and demand and deliver real benefits to travellers in the form of improved travel choice, time savings, cost reductions, and better service experiences. [12]

Figure 4: MaaS builds all services and functions around the customer

Illustrative MaaS customer framework



Source: LVM Ministry of Transport and Communications

See *The future in a MaaS world* for a narrative of an imagined customer journey from an office-to-home. Some of what's portrayed may seem a stretch from today's vantage point, but as Bill Gates remarked about technological change:

> "We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten."

MaaS outcomes will vary by urban geography, as well as by economic and demographic factors, which influence trip patterns and the quality of existing public transit systems. To support the provision of real time data for planning and services, all MaaS participating regions will need to have quality telecommunication infrastructure.

Several cities are already working towards a MaaS future, now.

Helsinki announced that by 2025, the city plans to make it unnecessary for any resident to own a private car. This is to be achieved, not by banning cars, but by building a transport system that makes them unnecessary.

The goal is an on-demand mobility system that would allow customers to choose among public and private transport providers and assemble the fastest or cheapest way of getting anywhere they need to go at any time.

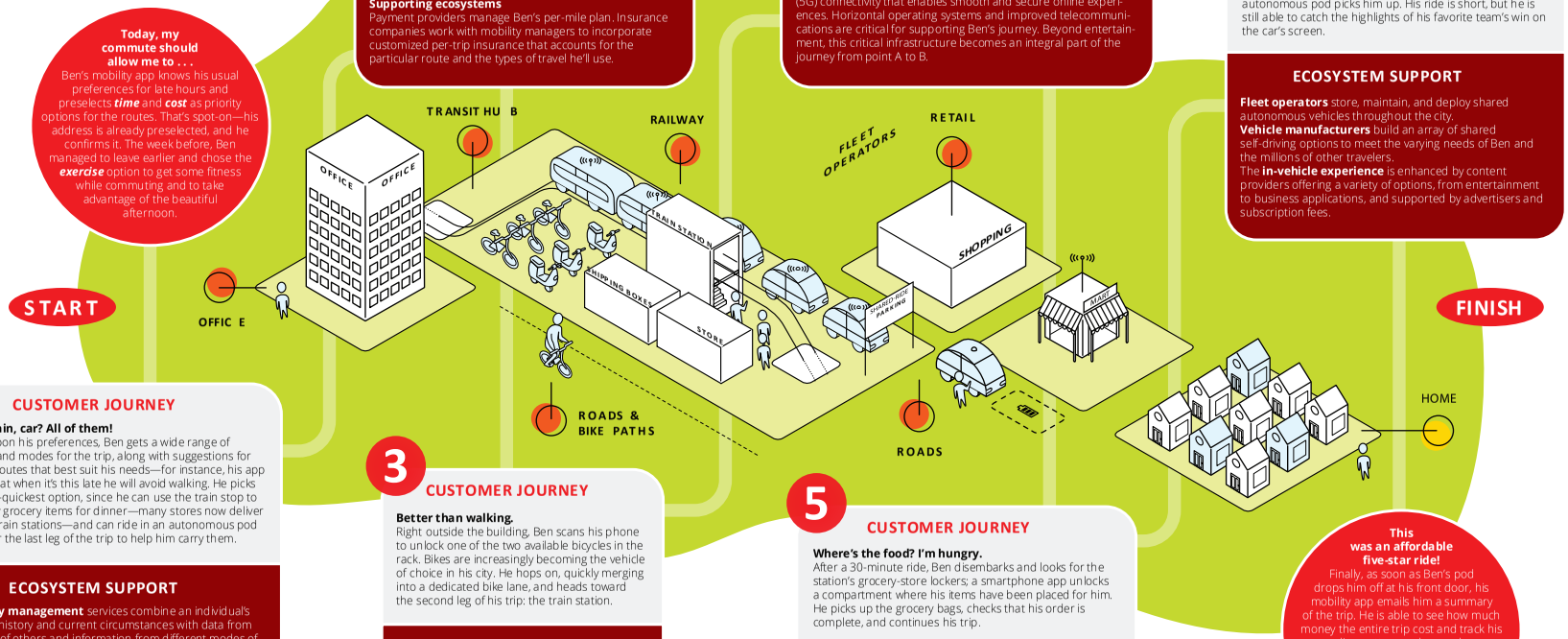
As it is, Helsinki has already progressed on one MaaS attribute — one account for all modes of transport. Since 2016, Helsinki residents have been able to use an app called Whim to plan and pay for all modes of public and private transportation within the city — be it by train, taxi, bus, carshare, or bikeshare.

Anyone with the app can enter a destination, select their preferred mode of getting there — or, in cases where no single mode covers the door-to-door journey, a combination of transport types — and go. Users can either pre-pay for the service as part of a monthly mobility subscription, or pay as they go using a payment account linked to the service.[13]

While Helsinki may be the poster child of the emergent MaaS movement, it is not alone. Paris, Eindhoven, Gothenburg, Montpellier, Vienna, Hanover, Las Vegas, Los Angeles, Denver, Singapore, and Barcelona have all piloted local versions that span the spectrum from modest peer-to-peer (P2P) offerings to integrated public transportation to combined mobility services that include both public and private-sector players.[14]

The future in a MaaS world [15]

OK, I'm ready to go.
Ben is ready to go home. It's almost 8 p.m., a testament to his unpredictable workload: He leaves at a different time each day, facing a range of traffic conditions. Ben has a busy life, and it's important for him to make the best of his commute. As he heads to the elevator, he pulls up his smartphone and checks out his best route options.



1 CUSTOMER JOURNEY

Bike, train, car? All of them!
Based upon his preferences, Ben gets a wide range of options and modes for the trip, along with suggestions for the top routes that best suit his needs—for instance, his app knows that when it's this late he will avoid walking. He picks the third-quickest option, since he can use the train stop to get a few grocery items for dinner—many stores now deliver to busy train stations—and can ride in an autonomous pod home for the last leg of the trip to help him carry them.

ECOSYSTEM SUPPORT

Mobility management services combine an individual's specific history and current circumstances with data from millions of others and information from different modes of travel across the city. Using advanced analytics, they offer users tailored, seamless options.

2 CUSTOMER JOURNEY

Within my budget and all in one fare!
Ben gets a single fare estimate for his entire selected trip, which includes details for each segment's costs. He uses a pay-per-mile system, which allows him to move seamlessly—and use multiple modes—through a single mobility platform. Immediately after committing to his route, Ben receives an electronic ticket on his cellphone for the entire itinerary.

ECOSYSTEM SUPPORT

Supporting ecosystems
Payment providers manage Ben's per-mile plan. Insurance companies work with mobility managers to incorporate customized per-trip insurance that accounts for the particular route and the types of travel he'll use.

3 CUSTOMER JOURNEY

Better than walking.
Right outside the building, Ben scans his phone to unlock one of the two available bicycles in the rack. Bikes are increasingly becoming the vehicle of choice in his city. He hops on, quickly merging into a dedicated bike lane, and heads toward the second leg of his trip: the train station.

ECOSYSTEM SUPPORT

Physical infrastructure
City planners work closely with the private sector to operate and maintain critical infrastructure, from bike racks to train platforms. Those physical assets are increasingly smart and connected, allowing constant, real-time monitoring.

4 CUSTOMER JOURNEY

Let me run some errands.
After a smooth ride, Ben parks at the station's bike rack near the entrance. His smartphone, sitting in his pocket, sends an electronic signal enabling him to access the platform and board the train. While en route, Ben shops for a few grocery items he needs for dinner. The in-app selection is a little restricted, a natural constraint of having fresh groceries available at the station upon his arrival.

ECOSYSTEM SUPPORT

Digital infrastructure providers offer ubiquitous, high-speed (5G) connectivity that enables smooth and secure online experiences. Horizontal operating systems and improved telecommunications are critical for supporting Ben's journey. Beyond entertainment, this critical infrastructure becomes an integral part of the journey from point A to B.

5 CUSTOMER JOURNEY

Where's the food? I'm hungry.
After a 30-minute ride, Ben disembarks and looks for the station's grocery-store lockers; a smartphone app unlocks a compartment where his items have been placed for him. He picks up the grocery bags, checks that his order is complete, and continues his trip.

ECOSYSTEM SUPPORT

Retailers and logistics providers have reconfigured operations to enable nearly on-demand provisioning of products to consumers.

6 CUSTOMER JOURNEY

My ride awaits . . .
Toting shopping bags, Ben walks toward the rideshare pickup area outside of the train station, where his autonomous pod picks him up. His ride is short, but he is still able to catch the highlights of his favorite team's win on the car's screen.

ECOSYSTEM SUPPORT

Fleet operators store, maintain, and deploy shared autonomous vehicles throughout the city.
Vehicle manufacturers build an array of shared self-driving options to meet the varying needs of Ben and the millions of other travelers.
The **in-vehicle experience** is enhanced by content providers offering a variety of options, from entertainment to business applications, and supported by advertisers and subscription fees.

This was an affordable five-star ride!
Finally, as soon as Ben's pod drops him off at his front door, his mobility app emails him a summary of the trip. He is able to see how much money the entire trip cost and track his spending pattern and accruals over the course of the month. He is able to rate his ride, and the trip overall, as well as provide feedback and report any issues back to the mobility system.

MASS TRANSPORT WILL STILL BE NEEDED

The role of ride-hailing and car-sharing, and other non-personal car ownership models feature prominently in much of the research around MaaS. However, public transport, especially trains, will be integral to a MaaS future.

It is difficult to conceive of a circumstance where even ubiquitous autonomous vehicles, as part of a massive take-up of ride-hailing type-services, could on their own successfully address congestion issues especially in large cities.

Here's some context from recent observations.

In California, the average occupancy of an Uber vehicle in traffic was found to be 1.66, including the driver. This means that an Uber carries on average 0.66 of a passenger per trip, which further means that a third of all Uber vehicles on roads carry no passengers at all at any given time.[16]

No matter how narrow the lanes or how well-platooned the autonomous vehicles may be in future, a highway is unlikely to be as efficient at moving large numbers of people as a rail line or bus rapid transit (BRT), since even a fleet of autonomous pods cannot create similar passenger density as a fixed route bus at full or near capacity.[17]

An autonomous vehicle can only carry a finite number of passengers, which for the roomiest SUVs sits at around eight. A typical subway car can carry 100 passengers. Assuming a train has ten cars, that's 1,000 passengers per train. (A frequency of one train arriving every two minutes would result in a capacity of around 30,000 passengers per hour.)[18]

Imagine the same number of commuters trying to cram into a fleet of autonomous pods, at eight per vehicle, and making their way to the centre of a major cities like Sydney, London or New York during Monday morning rush hour. It would take around 3,750 autonomous pods per hour to keep up with that demand.[19]

It underscores *The Economist's* comment that, "even after [autonomous vehicles] arrive, mass transit systems will often remain the best way to move large numbers of people swiftly."

It supports the contention that the MaaS world would see a blurring of boundaries among private, shared, and public transport.

Mobility would most likely be delivered through a combination of self-driving, shared vehicles, with high-quality public transport as the backbone. All of this would be enabled through the use of smart software platforms that manage multimodal traffic flows and deliver mobility as a service.

Consequently, collaboration and partnership across all components of the mobility value-chain will be necessary for MaaS realisation. See *Cooperation to make MaaS possible* for more on this.

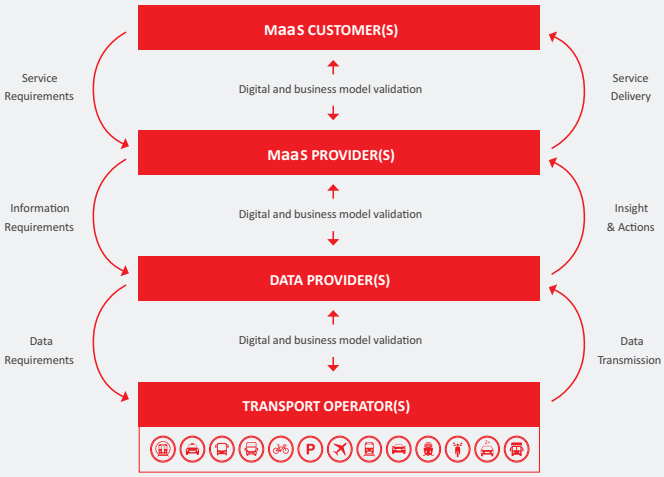
COOPERATION TO MAKE MAAS POSSIBLE [20]

MaaS, as is conceived, is data-driven, user-centred, powered by the growth of smartphones. To work effectively, MaaS would require the following conditions: widespread penetration of smartphones on 3G/4G/5G networks; high levels of connectivity; secure, dynamic, up-to-date information on travel options, schedules, and updates; and cashless payment systems.

To enable these conditions, a diverse range of actors would need to cooperate: mobility management players, telcos, payment processors, public and private transportation providers, and local authorities with responsibility for transportation and city planning.

Also required would be thoughtful integration of physical infrastructure (**Figure 5 on next page**) that enables transfer between transportation services, such as bus and subway interchanges, or bike and parking spaces at stations. Transportation planners and existing owners of physical infrastructure will have to think deeply about how various provider parties would link up.

Figure 5: Every part of the mobility value-chain has to work together to make MaaS succeed



Source: *Mobility as a Service – Expoloring the opportunity as a service in the UK*. Transport Systems Catapult. July 2016

DATA PROVIDERS

The data provider is one of the intermediary layers between the transportation operator and the end user. It manages the data exchange between the multiple service providers, providing the application programming interface (API) gateways and analytics on usage, demand, planning, and reporting.

Because individual service providers may not be likely to share their app data, having a third party involved can remove some of the barriers to cooperation that would otherwise arise. Data protocols will be a critical enabler and brings with it key matters for consideration around privacy and cyber security.

TRANSPORTATION OPERATORS

Essential to any MaaS offering, of course, are its largest players, the public transportation operators. Demands to expand service delivery have driven many transportation agencies to introduce new modes of travel, such as bikesharing, or to join up with complementary modes, such as carsharing.

For example, in Quebec, some municipal transportation authorities have offered mobility packages that include bikesharing and carsharing provided by Communauto, a private-sector concern.

Gaps in public transportation services have fuelled a growing army of small-scale private providers, each offering a specific service: parking, carpooling, peer-to-peer car clubs, ride-hailing, or on-demand bus rides. Typically, each operator requires its own app, with a separate interface and payment mechanism, and each service maintains its own customer relationships.

TRUSTED MOBILITY ADVISOR

The newest and most integral component of MaaS consists of third-party aggregators. Using an asset-light model similar to Alibaba, Airbnb, or Uber, the mobility advisors link the services of the various private and public operators, arranging bookings and facilitating payments through a single gateway.

Accomplishing that kind of integration has proven to be such a hurdle that only a few services have emerged in this category. UbiGo had a small pilot run in Gothenburg, Sweden, that was expanded in late 2016.

Helsinki's MaaS. fi pilot, which ran at the start of 2015, has relaunched as a private-sector start-up, MaaS Global. In Germany, Deutsche Bahn's Qixxit is a nationwide scheme that provides public and private journey planning and allows for one-stop payments within its app.

ROLE OF PUBLIC POLICY AND PUBLIC TRANSPORT

Governments will likely play a critical role, both by setting regulation and by serving as a "conductor" of sorts, enabling the ecosystem of MaaS' constituent pieces to work seamlessly together.[21] In fact, governments may be more impactful and efficient acting in a conductor capacity rather than as a transportation services provider.

Through smart partnerships between the public and the private sector and by potentially joint venturing strategic parts of the city's mobility networks to complementary service providers, MaaS would facilitate more effective use of existing infrastructure, and also ease pressure on transportation networks, thus enabling better traffic and capacity management.[22]

As it is, many transport agencies around the world are already investing in integrated fare payment, journey planning, and network and operations management technologies — platforms that present the transit network as an integrated system and enable the linking of various accounts into a single identity for the user.

Those solutions are often technologically sophisticated and designed in a way that ensures each agency receives the right amount of revenue, even in scenarios where fare structures are extremely complex.

They could easily become the core of future MaaS solutions, not only allowing transit operators to extend the technology to alternative transportation providers but also securing some quick wins for a city, and allowing the agencies to get a return on investment, while improving the overall customer experience for citizens.[23]

Furthermore, many of those platforms are also accessible through web and conventional telephone, allowing all types of customers to benefit from those innovations, making them even more suitable to become the backbone of future MaaS systems.

By assuming the role of facilitators of the MaaS transformation, public transport agencies can also help to ensure that MaaS initiatives support the efficient use of existing infrastructure and the funding of new infrastructure. Leveraging the data from the MaaS network, transport agencies could drive smarter use of existing industrial corridors, roadways, walkways, parking, etc., in the future mobility mix, as well as directing revenues toward the most efficient investments in new transportation infrastructure.[24]

For instance, cities that incorporate private ride-hailing services into the wider public mobility offering might set aside some of the revenue earned through such schemes toward the maintenance of public roads or the public transport network. Or, in a different scenario, they might charge the private operator for the privilege of using the road — a public asset — in pay-per-mile schemes.[25]

Fees might be dependent on several factors. Electric cars, cars with more than one passenger, or vehicles serving typically underserved areas might pay less. Those operating in city cores during peak hours might be charged more.

Alternatively, cities might allow ride-hailing companies to make use of public parking in order to limit congestion on the streets and eliminate unnecessary traffic caused by circulating Uber or Lyft cars in exchange for a fee, sharing data or some other benefit. Sao Paulo, Brazil is one example of a city that's already experimenting in this direction, while in Chicago, city authorities already charge a 67-cent tax on each ride-hailing trip. [26]

These are ultimately questions for policy makers. The important thing to understand is that MaaS platforms will be reliant on government facilitation to work seamlessly, and governments will be equally reliant on MaaS adoption to optimise the transport networks of the future. [27]

Government facilitation of MaaS would provide policy makers with unprecedented visibility on how the transport network is being utilised, while also providing a broader set of options to send "price signals" to users.[28] It could also assist in more efficient allocation of transport linked taxes back into infrastructure assets linked to patronage.

Creating a new mobility paradigm is a sizeable undertaking. How governments develop balanced regulatory frameworks to enable and monitor the collection, analysis and protection of sensitive personal data is one key challenge currently being contemplated.

IMPLICATIONS FOR INFRASTRUCTURE INVESTORS

The balance of power between consumers and service providers is shifting across all infrastructure sectors as consumer choice and technology combine to challenge traditional business models. This shift is particularly evident in the transport sector, where MaaS is prompting investors to think beyond traditional linear value chains to understand how their assets can provide utility as part of a more integrated system.

There are estimates that a seamless mobility ecosystem could lead to an increase in personal travel by 20 to 50 percent due to cost efficiencies, convenience and time savings. This would have an obvious flow-on effect to existing road, rail and other transit systems.

Tollroads may potentially realise significant benefits from the increase in personal travel by virtue of the fact that a large portion of MaaS trips will likely start and end with some sort of road vehicle-based "first/last mile" trip leg. This could be via personal vehicles, ride-sharing, carpooling, public bus or on-demand shuttles.

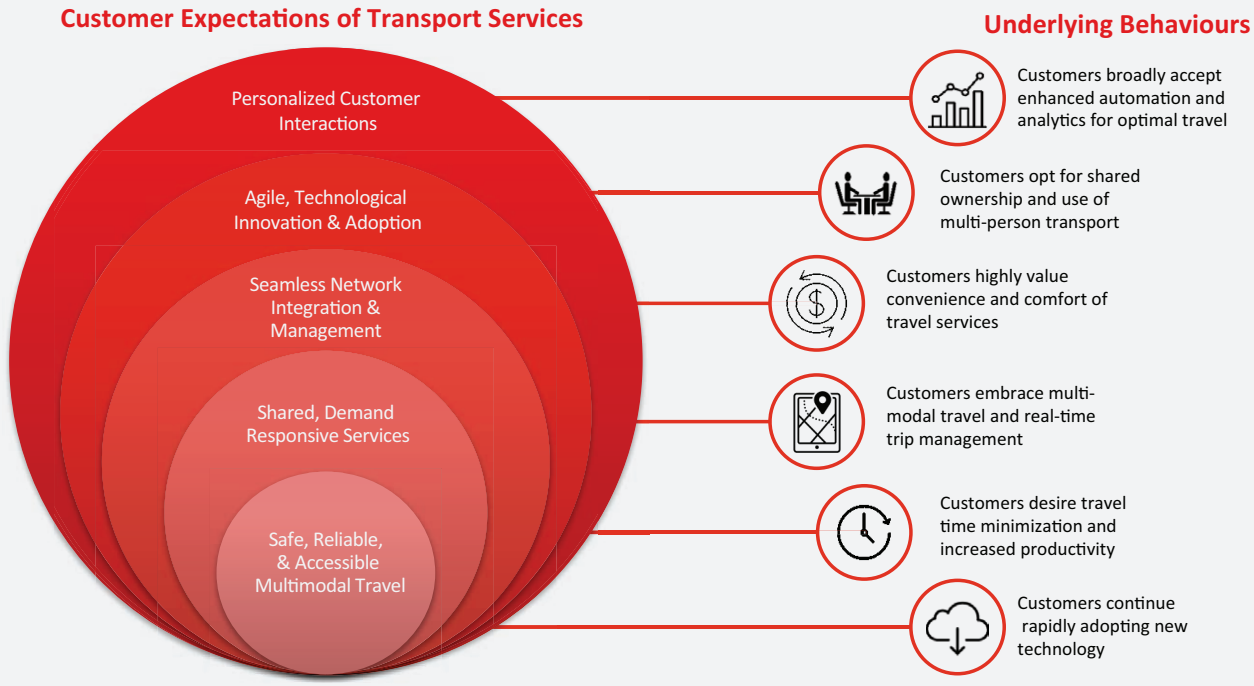
Time sensitive consumers may elect to avoid a modal switch and, if possible, continue their journey without any need for a modal transfer. Alternatively, real time data and trip planning may provide users with substitutes for existing toll roads by utilising suburban arterials, particularly commuters that are less time sensitive. Operators are beginning to create flexible, tailored products for customer preferences; such as dedicated lanes, carpooling discounts and demand based pricing, and the like.

The introduction of road user pricing in the future (depending on form and scope) also has the potential to significantly change

customer behavioral patterns around mode choice and route choice (**Figure 6**).

Associated with this would be potentially significant implications for tollroad owners now and future tollroad investments. There will be key nodes generated by demand, which will need to be reimagined with different configurations for customers using and departing from different modes of transport.

Figure 6: A new ballgame of customer preferences will need to be understood



Sources: Transport for NSW, 2016. Future Transport Technology: Roadmap 2016; Transport for NSW, 2017. Connections: Towards 2017.

Strategic business planning and active asset management will be critical. How an infrastructure operator future proofs its assets to ensure compatibility with new technologies and regulations will be critical to an asset's success. MaaS platforms will become everyday considerations for tollroad operators, as the scope of their service provision and social license continues to expand.[32]

Mass transit rail services will continue to be a vital part of the mobility ecosystem, offering great speed and capacity. MaaS technology is expected to drastically increase the efficiency and usability of mass transit rail. Technological innovations will lead to seamless connectivity with mass transit services, which will ultimately reduce user waiting times and the impacts of service disruption; as users will instantly and seamlessly be offered integrated alternatives should a service be cancelled.[33]

The integration of carpooling and/or ride-sharing to complete the "last mile" of mass transit journeys will be particularly attractive to potential customers that currently opt for alternate modes of transport due to difficulties getting either to, or from, a station. These factors, combined with the existing investment thematics associated with mass transit rail; urbanisation, limited competition, would seem to make rail an attractive investment sector.[34]

Car parking will continue to play a critical role in transportation ecosystems. Opportunities stemming from widespread uptake of MaaS platforms will vary significantly depending primarily on location, length of stay and the level of trip optionality introduced by MaaS.[35]

This makes car parking an investment sector that requires deep sector-specific knowledge to identify attractive assets, with high demand generators in locations that could be described as "franchise areas."

Negotiating flexible concession agreements and applying an active approach to asset management is also critical to ensure that car parks can be effectively adapted to respond to the evolution of MaaS, in particular, the likely integration of ancillary mobility services such as car fleet management.

Finally, infrastructure investors must play a central role in transport policy discussions. Regulation can either be a potential accelerator or handbrake for the development of MaaS and thus will require informed engagement and stakeholder management by infrastructure owners. Service providers too need to be deeply engaged as the regulatory environment's evolution will profoundly impact their operations.

As the greatest transformation of the mobility ecosystem since the invention of the motorcar takes place, it is important infrastructure investors remain diligent with respect to their future acquisitions and actively manage their existing infrastructure assets to capitalise on the range of opportunities that will present themselves and be agile in responding to customer needs and new technologies.

This Red Paper results from a collaboration of the following people in the QIC Global Infrastructure team: Ross Israel, Matina Papathanasiou, Leisel Moorhead, Trent Carmichael, Kirsten Whitehead, Grace Tang, Tom Steinfort, Wade MacRae, and Albert Daniels.

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IMPORTANT INFORMATION

All figures are in U.S. dollars unless otherwise stated.