OPUS

Wellington Transport Research Series: Report 1

Transport Technology Opportunities for the Wellington Region

Review of Policy and Technology Trends

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Review of Policy and Technology Trends

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Contents

Document purpose

This document identifies the existing local and central government policy setting for technology and mobility in Wellington and New Zealand and describes in detail a range of emerging areas of mobility that are underpinned by technology and relevant to Wellington's vision.

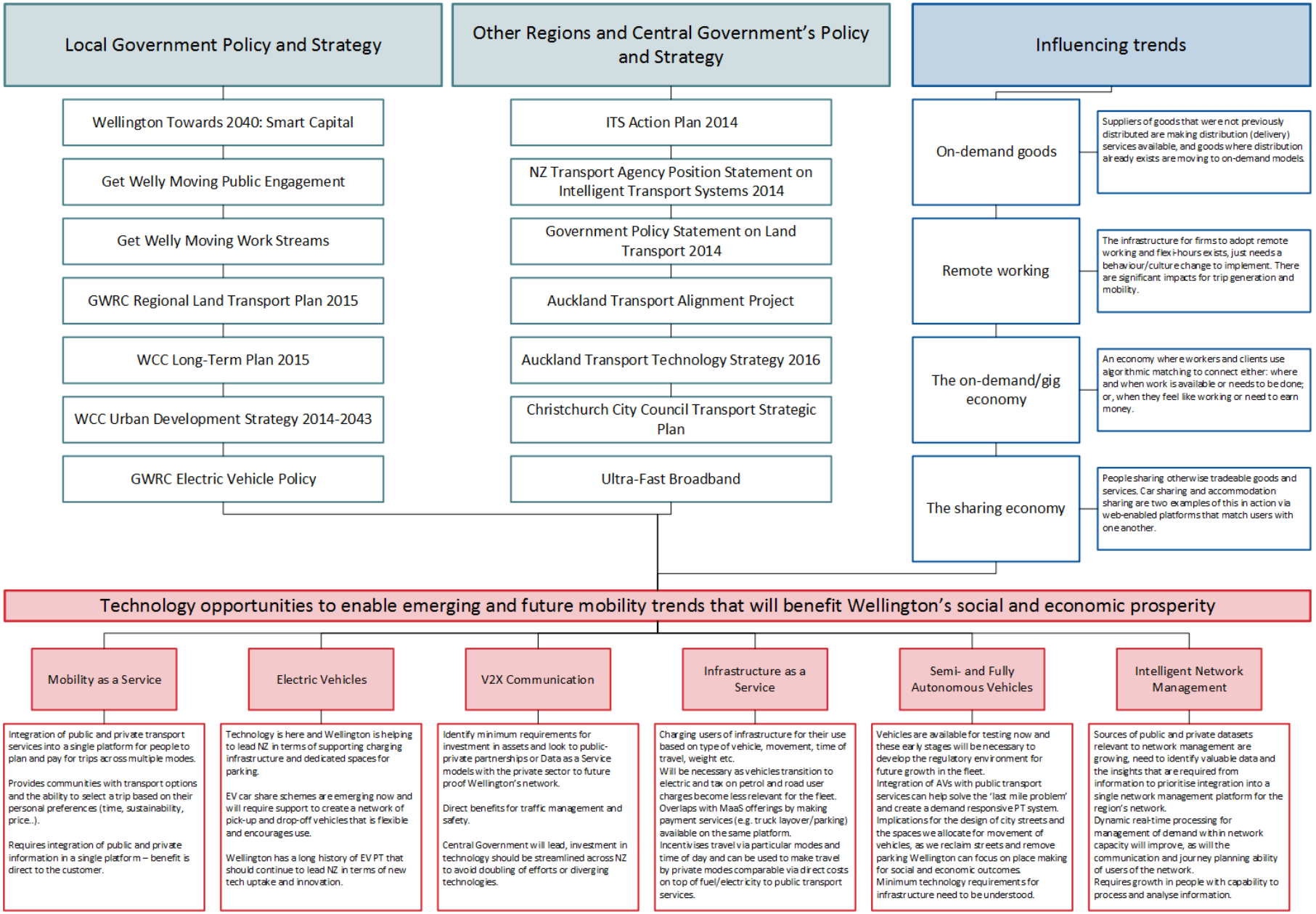
Technology is a core enabler of future mobility, be it future proofing our transport networks for the introduction of new on-road technology such as connected and autonomous vehicles, or to provide people with a much-improved transport experience by integrating multiple transport options into easy to use journey planning, and payment services.

Beyond this, technology investment alongside public and private initiatives and innovation will provide direct benefits to Wellington's people and businesses. It is this community that the transport network is there to serve and emerging technologies already place people at the centre of innovation with products increasingly tailored to cater for individual preferences and needs.

Behaviour change in how people access and use mobility services is expected to change, and in fact must change if issues such as congestion are to be addressed and we seek to return land in the central city to people rather than cars. Shared mobility, total mobility, end to end journeys and the problem of the last mile all require technology and not infrastructure solutions to make them feasible for day-to-day travel in people's lives.

This document is an internal working document for Opus' project team and guided the following research stages presented in Reports 2 and 3 of this research series. It is not intended for public release.

An overview of the content of this document is provided below:


Local Government Policy and Strategy
Wellington Towards 2040: Smart Capital
Get Welly Moving Public Engagement
Get Welly Moving Work Streams
GWRC Regional Land Transport Plan 2015
WCC Long-Term Plan 2015
WCC Urban Development Strategy 2014-2043
GWRC Electric Vehicle Policy
Other Regions and Central Government's Policy and Strategy
ITS Action Plan 2014
NZ Transport Agency Position Statement on Intelligent Transport Systems 2014
Government Policy Statement on Land Transport 2014
Auckland Transport Alignment Project
Auckland Transport Technology Strategy 2016
Christchurch City Council Transport Strategic Plan
Ultra-Fast Broadband
Influencing trends
On-demand goods
Suppliers of goods that were not previously distributed are making distribution (delivery) services available, and goods where distribution already exists are moving to on-demand models.
Remote working
The infrastructure for firms to adopt remote working and flexi-hours exists, just needs a behaviour/culture change to implement. There are significant impacts for trip generation and mobility.
The on-demand/gig economy
An economy where workers and clients use algorithmic matching to connect either: where and when work is available or needs to be done; or, when they feel like working or need to earn money.
The sharing economy
People sharing otherwise tradeable goods and services. Car sharing and accommodation sharing are two examples of this in action via web-enabled platforms that match users with one another.
Technology opportunities to enable emerging and future mobility trends that will benefit Wellington's social and economic prosperity
Mobility as a Service
Integration of public and private transport services into a single platform for people to plan and pay for trips across multiple modes.
Provides communities with transport options and the ability to select a trip based on their personal preferences (time, sustainability, price..).
Requires integration of public and private information in a single platform – benefit is direct to the customer.
Electric Vehicles
Technology is here and Wellington is helping to lead NZ in terms of supporting charging infrastructure and dedicated spaces for parking.
EV car share schemes are emerging now and will require support to create a network of pick-up and drop-off vehicles that is flexible and encourages use.
Wellington has a long history of EV PT that should continue to lead NZ in terms of new tech uptake and innovation.
V2X Communication
Identify minimum requirements for investment in assets and look to public-private partnerships or Data as a Service models with the private sector to future proof Wellington's network.
Direct benefits for traffic management and safety.
Central Government will lead, investment in technology should be streamlined across NZ to avoid doubling of efforts or diverging technologies.
Infrastructure as a Service
Charging users of infrastructure for their use based on type of vehicle, movement, time of travel, weight etc.
Will be necessary as vehicles transition to electric and tax on petrol and road user charges become less relevant for the fleet.
Overlaps with MaaS offerings by making payment services (e.g. truck layover/parking) available on the same platform.
Incentivises travel via particular modes and time of day and can be used to make travel by private modes comparable via direct costs on top of fuel/electricity to public transport services.
Semi- and Fully Autonomous Vehicles
Vehicles are available for testing now and these early stages will be necessary to develop the regulatory environment for future growth in the fleet.
Integration of AVs with public transport services can help solve the 'last mile problem' and create a demand responsive PT system.
Implications for the design of city streets and the spaces we allocate for movement of vehicles, as we reclaim streets and remove parking Wellington can focus on place making for social and economic outcomes.
Minimum technology requirements for infrastructure need to be understood.
Intelligent Network Management
Sources of public and private datasets relevant to network management are growing, need to identify valuable data and the insights that are required from information to prioritise integration into a single network management platform for the region's network.
Dynamic real-time processing for management of demand within network capacity will improve, as will the communication and journey planning ability of users of the network.
Requires growth in people with capability to process and analyse information.

1 Policy context

Both central and local government (in particular local authorities in Wellington) recognise the potential that established and emerging technologies have to positively impact transport and mobility locally across a range of plans, strategies and policy documents. Both central and local government in New Zealand are consistent in the view that technology is an enabler of change, supplementing rather than replacing established solutions. Where it does not provide explicit endorsement, central government is at least permissive of:

- Mobility as a service.
- Vehicle-to-everything communication.
- Technology enhanced network operations.
- Data as a service.
- Electric vehicles and associated infrastructure.
- Semi- and fully-autonomous vehicles.

1.1 Local Government

Wellington City Council's strategy *Wellington Towards 2040: Smart Capital* has set a clear strategic direction around the adoption of technology in support not only of Wellington becoming a smart city, but as an enabler of healthy and vibrant lifestyles for people[1]. This enables the transport system to be considered, not just from a utilitarian perspective, but from the point of view of people's enjoyment and satisfaction, recreation, health & activity, connecting people to the natural setting of their city and improving the traveler experience beyond just reducing delays, increasing efficiency and providing information.

In addition to *Wellington Towards 2040* both Greater Wellington Regional Council and Wellington City Council have recognised the significance of technology to delivering high-quality transport outcomes for the city, and set the scene for the use of these technologies in the following key documents:

- Greater Wellington Regional Council's Wellington Regional Land Transport Plan 2015
- Wellington City Council's Long-Term Plan 2015
- Wellington City Council's Wellington Urban Development and Transport Strategy 2014-2043

It is clear from both Wellington City Council and Greater Wellington Regional Council that, with regard to transport, technology should be applied to support the following outcomes:

- Reliable public transport and transport routes
- Improved safety across all modes
- A resilient and low impact transport network
- Integration between modes
- Increasing active transport
- Roads and public spaces (parks) as strategic transport assets.

Greater Wellington Regional Council comments specifically on the potential of EV, ridesharing, and fast broadband as tools to reduce the impact on the environment and demand on the transport network. Wellington City Council is less explicit, noting the supplementary role that technology plays alongside other tools available to local government[5], however WCC has shown leadership by

already working in conjunction with NEC to test centralising data to enable collaboration between agencies, and to deploy new sensors to civic operations.

With respect to transport systems, Christchurch City Council has recognised the potential benefits of technology (in particular noting the benefits for the environment) and recommends that technology should be considered for integration on a case-by-case basis[6]. Auckland Transport's plans are more comprehensive with the agency having adopted a technology strategy in June 2016. However, they also look at technology as supplementary rather than a standalone solution, commenting "a modern transport system requires technological "glue" to collect, process and utilise data to provide operational effectiveness, efficiency, safety and resilience across all transportation modes and services."[7] The Auckland Transport Alignment Project (ATAP), which included a technology workstream, recognised the importance of technology as a tool to manage travel demand and to enable more efficient use of existing networks. ATAP identified "accelerating the uptake of new technologies" as a medium to long term focus and wanted to "maximise benefits" from new technologies. (http://www.transport.govt.nz/land/auckland/atap)

However, it should be noted that post-earthquake Christchurch has been a leader in leveraging technology to engage the public[8,9,10], quickly realising the potential of technology not only to reach a wider audience, but to aide people's understanding of a transport system in a state of flux and to collect their thoughts and desires for the rebuild of their transport system. This enabled a wide range of people to get participate in a genuine way, technology was critical in equipping the public to take part.

1.2 Towards 2040: Smart Capital

Wellington Towards 2040: Smart Capital Wellington's 30-year strategy for future development is a vision supported by four city goals: a people centred city; an eco-city; a connected city; and a dynamic central city. The scenarios developed by Get Welly Moving and the investment that will take place in prioritised transport and mobility projects will be a core enabler of all four Smart Capital goals.

Wellington's transport network and central city spaces are competing for space and the city's connections to the wider region have heavy congestion with the worst spikes in travel times at peak commuter periods in the country. New infrastructure and better public transport services will help to alleviate some of this burden but, certainly in the medium to longer term, Wellington will not be able to build its way out of congestion and poor connectivity.

Technology will play a key role in the future of mobility in Wellington to get people out of their cars and using more efficient modes such as public transport (on a reliable and accessible network) and shared services. The impact of public and private mobility services will be 'unlocked' by technology as multi-modal trips are integrated into single online platforms that provide people with the ability to plan and pay for journeys on the fly. Technology will also be an important facilitator of incentivising non-car based travel and discouraging solo car travel to certain areas or at particular times of day.

The goals of Wellington's Smart Capital vision will be drivers of smart transport infrastructure investment and strategy. This approach places social and economic development at the core of transport decision making and positions transport as an enabler of growth in these areas. Intelligent mobility is not just about solving current transportation issues but about creating liveable cities that attract talent and businesses and promote a high quality of life for residents.

While setting goals for Smart Wellington, the document itself does not mandate specific investments in technology, and there are a number of challenges and influences that will shape how these goals are achieved. Technologies implemented will be swayed by public opinion, openness (or resistance) to change, the availability and reliability of technology, and 'game changing' decisions made by central government and private companies who are also involved in this space.

Any future planning for investment in technology solutions to achieve Wellington's Smart Capital goals will need to consider timing and the useful life of investments – when do you plan to implement and how long will the implementation last? There are quick wins to be made but these should not be at the expense of high ongoing costs, or technologies that meet Wellington's goals now but not in ten years' time.

Wellington City Council. Wellington Towards 2040: Smart Capital. http://wellington.govt.nz/~/media/your-council/plans-policies-and-bylaws/plans-and-policies/a-to-z/wellington2040/files/wgtn2040-brochure.pdf

1.3 Central Government

Where local government in Wellington has set the strategic direction for the application of technology, central government provides the framework to limit or enable to application of technology in general, and specific technologies in particular. The key central government documents that set the scene for transport and technology (more specifically Intelligent Transport Systems or ITS[11]) include:

- NZ Transport Agency Position Statement on Intelligent Transport Systems, 2014.
- Government Policy Statement on Land Transport, 2014.
- Intelligent Transport Systems Technology Action Plan 2014-18, 2014.
- Ministry of Transport Domain Plan, 2016.

More generally, central government has recognised the potential of technology to transform the way New Zealand works, and has developed a policy and regulatory framework with a particular focus on realising the economic benefits to the nation. This has involved an investment of $1.35 billion in deploying future proofed high-speed broadband infrastructure and making sure that services over that infrastructure are affordable for households and small businesses[12], as well as a regulatory review of pricing of services to ensure accessibility[13].

Central government is explicit in endorsing the use of new technologies to enhance transport in Aotearoa / New Zealand commenting that ITS is a tool that will aide in delivering an effective, efficient, resilient, and safe transport network in Aotearoa / New Zealand[14], and that technology offers "*considerable scope for innovation in the way that the land transport system is delivered.*"[15] Specifically, central government notes that ITS presents opportunities to enhance[16]:

- "the way we gather and use data about traffic flows and the state of the network
- the amount and quality of data
- our ability to communicate with travellers
- our ability to resolve operational issues in the transport network
- our ability to protect people from their and others' mistakes."

NZTA has recognised three strategic advances that are important enablers of these opportunities[17]:

- The ubiquity of smartphones and related location information
- The potential positive impact of autonomous and sensor equipped vehicles
- Improved vehicle identification technologies including in-vehicle chips and road-side sensors.

As well as a general acknowledgement of the opportunities related to ITS / emerging technologies, the central government has signaled its support for:

- Electric vehicles - in 2016 the Ministry of Transport launched the Electric Vehicle Programme to increase uptake of electric vehicles in Aotearoa / New Zealand[18].
- Autonomous vehicles - the Ministry of Transport has published guidelines for trialling autonomous vehicles in Aotearoa / New Zealand[19].
- Ride-sharing - the Land Transport Amendment Bill 2016 removes outdated provisions and caters for the use of new technologies that facilitate ride-hailing, carpooling, transportation network companies and other micro-transit services[20].

1.4 Barriers

Government strategy around transport and technology has a a common weakness that is only starting to be addressed now: whilst technology is an enabler to delivering existing policy, services and enhancing infrastructure, the potential for technology to deliver on more human-centred objectives e.g. vibrant or connected communities, improving health and wellbeing and creating more place attachment or a sense of belonging has not been embraced and integrated into strategy and direction. The smart city movement has begun to discuss how cities can use technology to grow social capital, become more compassionate, reach and engage more effectively with citizens through digital democracy, thereby growing trust in government and creating social stability[1] & [2]. Leading cities are beginning to embrace these aspirations and embed them into policy and strategy.

Except for legislative reform to reduce **the barriers to adopting new technology** (e.g. to the widespread adoption of ride-hailing services like Uber[21]), central government has largely focused on providing signals to the market, with **little explicit funding for new technologies**. This means that, with respect to investment in transport technologies, it will largely need to draw on existing transport budgets (reallocation of funds), and co-investment between local and central government, and between government and the private sector.

An **integrated approach to funding technology** is not a bad approach at a local government level i.e. providing general funding for transport outcomes, and setting a clear strategic direction that recognises technology as a tool. However, this **does not recognise the adjustment costs** that agencies are going to need to incur over the short term in order to put in place not only new technology, but the systems and processes to integrate it effectively rather than simply becoming an add on. Already there are technologies being trialed by the private sector working in partnership with local government agencies (e.g. NEC is trialing sensor technology with Wellington City Council[22,23]). While trials are a good way to explore the effectiveness and relevance of a range

[1] https://www.budde.com.au/Research/Smart-Cities-How-cities-can-contribute-to-social-stability-and-security?r=70

[2] http://smartcitiescouncil.com/article/compassionate-cities

of technologies, **a lack of explicit funding means local government is dependent on the private sector to upscale these solutions**. This limits a local authority's ability to critically explore solutions and places any 'smart city' goals at risk of "pilot sickness"[3].

Following Get Welly Moving's effective public engagement exercise, much of which took place online, the **public** will have an **expectation** that they will be listened to again in the future and there will be **pressure on government to respond quickly**, or even in realtime to requests, suggestions and challenges. In addition, new services, such as micro-transit and shared ridehailing are demand responsive, which is good when the services flexes to meet your needs, but could leave people stranded and unable to reach essential services if demand is too low. Government therefore has a new role in regulating or incentivising providers of these services to ensure that they are flexible, but that levels of service, hours and areas of operation work for its citizens. In addition, as pilot services are provided and prove their worth, government needs to be able to respond quickly to formalise and roll them out to benefit businesses and citizens.

Technological change and innovation is moving at rapid pace and often policy struggles to keep up. This can result in opportunities to take advantage of new services or improve transport experiences being delayed or blocked. For example evidence is available from the USA that the new ride-hailing and micro-transit services are more effective in increasing vehicle occupancy than carpooling, and yet the New Zealand government has renewed its national *carpool* provider rather than revisiting all of the ridesharing options and reconsidering which new services would be most effective in increasing vehicle occupancy.

While **more flexibility and responsiveness to demand** would be welcomed by travellers, i.e. "bottom up" organisation, there is also **a need to organise the transport system** to deliver access and this may require, for example, new approaches to "top down" planning e.g. geo-fencing permitted areas of operation, mandating the provision of some more marginal services by operators that win the rights to deliver commercially viable services.

Another barrier to roll out is **how quickly technology is changing**, particularly hardware, so selection can be difficult and there is a risk of inertia when decision makers become too concerned about technology becoming obsolete or want to wait until the cost falls. **Customer costs of mobile technologies** are also problematic as we shift toward delivery of services via apps that require smartphones to be a part of the system. Mobility services need to consider groups with limited access to such technology and ensure that a divide is not created between groups.

In New Zealand, **internet availability outside of the main centres**, can be limited and not necessarily at great distance. Places close to Wellington city such as Makara have limited internet access for mobile devices.

Finally, a range of political and commercial barriers exist that are centred mainly around issues of **privacy, security, data sensitivity, commercial value, and standardisation**. Much of these challenges can be addressed with technical investment, however the issue of commercial sensitivity is likely the greatest barrier to be overcome in the smart mobility sector. Public-private partnerships will go some way to reducing any negative effects of such concerns on progress and innovation, however examples of these partnerships are limited at present.

[3] http://smartcitiescouncil.com/article/want-be-global-smart-cities-leader-keep-eye-denmark

2 Tech trends + opportunities

2.1 Mobility as a Service

Mobility as a Service (MaaS) is a vision of transportation modes being consumed as a service instead of the current model of heavy reliance on private modes of transport supported by a range of disparate public (e.g. public transport) and private (e.g. taxi and ride hailing services) transport options. MaaS has been proposed as a solution not only for people's journeys but also as an efficient solution for the movement of goods in cities.

Central to this is a system that unifies all available transport services into a single gateway accessed by travellers who can plan their journey; are provided with options and choice that meet their needs; and then pay for a trip across multiple modes from a single account. Integrating ride-hailing, ride-sharing, bikeshare, car-share, and even freight transport as a service information with more traditional public transport, taxi and freight/courier information into a single platform will enable travellers to compare travel times, options and price across modes and services in a transparent manner.

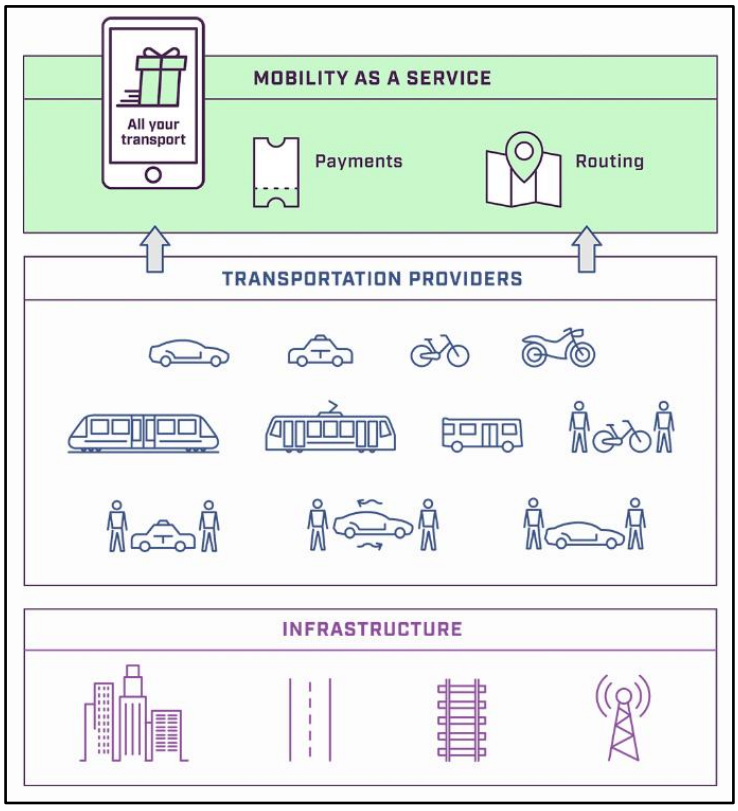


Figure 2-1: MaaS platform structure (https:// http://maas.global/whim/).

While this would shift how mobility is currently provided in Wellington, there is evidence of public appetite for such changes in the personal mobility sector. MaaS is attractive to travellers not only because it makes trip planning easy, but also because it can offer, for example, a fixed monthly price for all travel.

Internationally, Helsinki became the world's first capital city to include their regional public transport system in a MaaS application called Whim. This service includes taxis and rental cars and

allows users a set amount of travel based on monthly subscription packages. For the equivalent of NZ$140, the 'light' subscription option, users gain access to unlimited local public transport and two taxi trips a month. There is a pay-as-you-go option and users can also opt to pay more to increase their unlimited public transport service to a regional level.

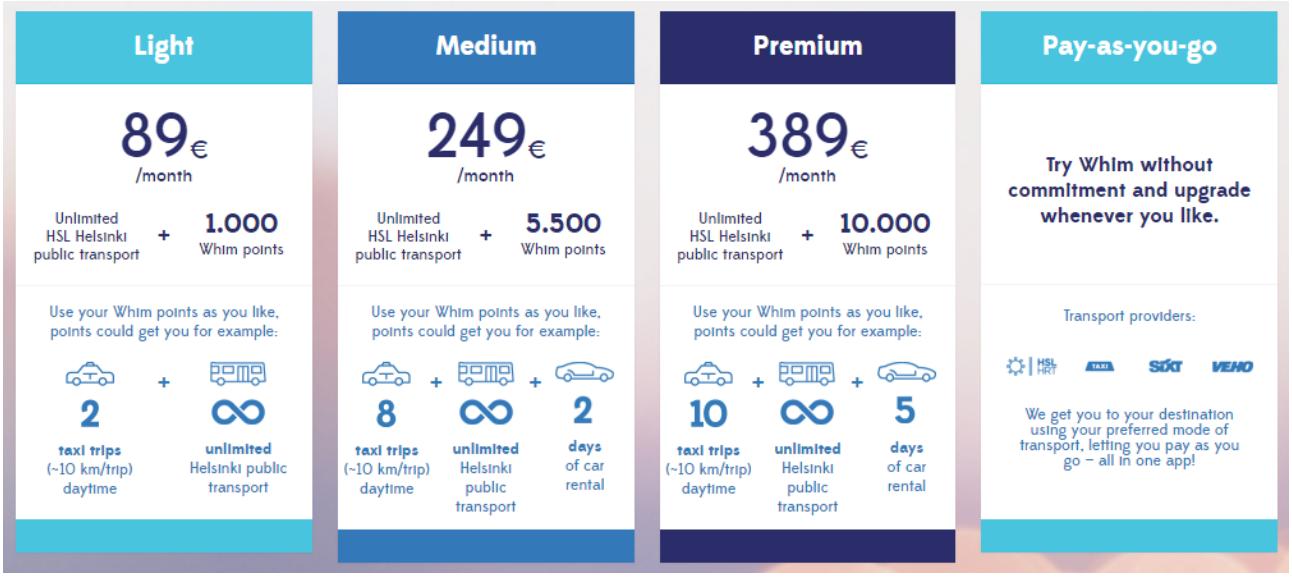


Figure 2-2: Helsinki's MaaS packages offered on Whim's platform (https://whimapp.com/fi-en/)

In New Zealand, the Transport Agency are actively exploring the potential for MaaS offerings for travel, the implications for Wellington will be primarily around the inclusion of public transport services in a local app and the data requirements that are needed to be successful.

This will have implications for how public transport services are provided, especially if local, regional and national services can be paid for in the same app and users can gain access to the same unlimited use type of offering as seen in Helsinki.

An appropriate data policy across public transport contracts will be essential as an enabler of shifting toward a future MaaS model, without this, the ability of Wellington's public transport services to be integrated into a single platform with other modes will be unfeasible. At present the provision of regional public transport is discordant with separate ticketing systems for bus and rail, though travellers can plan journeys across both modes using the Metlink platform. In addition, MaaS users will need to be able to rely on trip/ wait time predictions in order to complete multi-modal trips on time, including interchanges and waits.

In a country of New Zealand's size a national MaaS approach makes sense particularly to reduce the cost burden on individual authorities who might otherwise invest in a system for their own network, with payment rates based on local and regional models. The conversation will be led by the Transport Agency and Wellington is in a strong position, alongside Auckland, where the network coverage and patronage of public transport is relatively high compared to the rest of the country so innovation and testing of new delivery models is a viable prospect.

Department for Transport. *Feasibility Study for "Mobility as a Service" concept in London.* https://www.bartlett.ucl.ac.uk/energy/docs/fs-maas-compress-final

Federation Internationale De L'Automobile. *'Mobility as a Service' – the new transport model?* http://www.fiaregion1.com/download/events/its_supp_et214.pdf

MaaS Global. *Helsinki takes another pioneering step in mobility services: HRT public transport added to the Whim mobility app*. https://maas.global/helsinki-takes-another-pioneering-step-in-mobility-services-hrt-public-transport-added-to-the-whim-mobility-app/

ITS International. *Mobility as a Service gaining traction in US and Europe*. http://www.itsinternational.com/sections/transmart/features/mobility-as-a-service-gaining-traction-in-us-and-europe/

MaaS Alliance. http://maas-alliance.eu/#MAAS

2.1.1 Wellington's Mobility as a Service opportunities

- Develop a new model for provision and access to public transport services in the Wellington region that is integrated with other public and private services
- Follow other international cities in the provision of MaaS and provide a model that can be replicated/ applied by other regions in New Zealand
- Increase transparency and transport options for travellers in Wellington and provide users with better ability to plan trips other than solo-car driving, across multiple modes
- Attract new mobility service providers into Wellington's market as the region becomes recognised as a test-bed for innovation and grow the opportunity for citizens to realise the economic opportunities in the sharing economy
- Contribute to the development of national data standards and standards for integration of public and private information in an API environment.

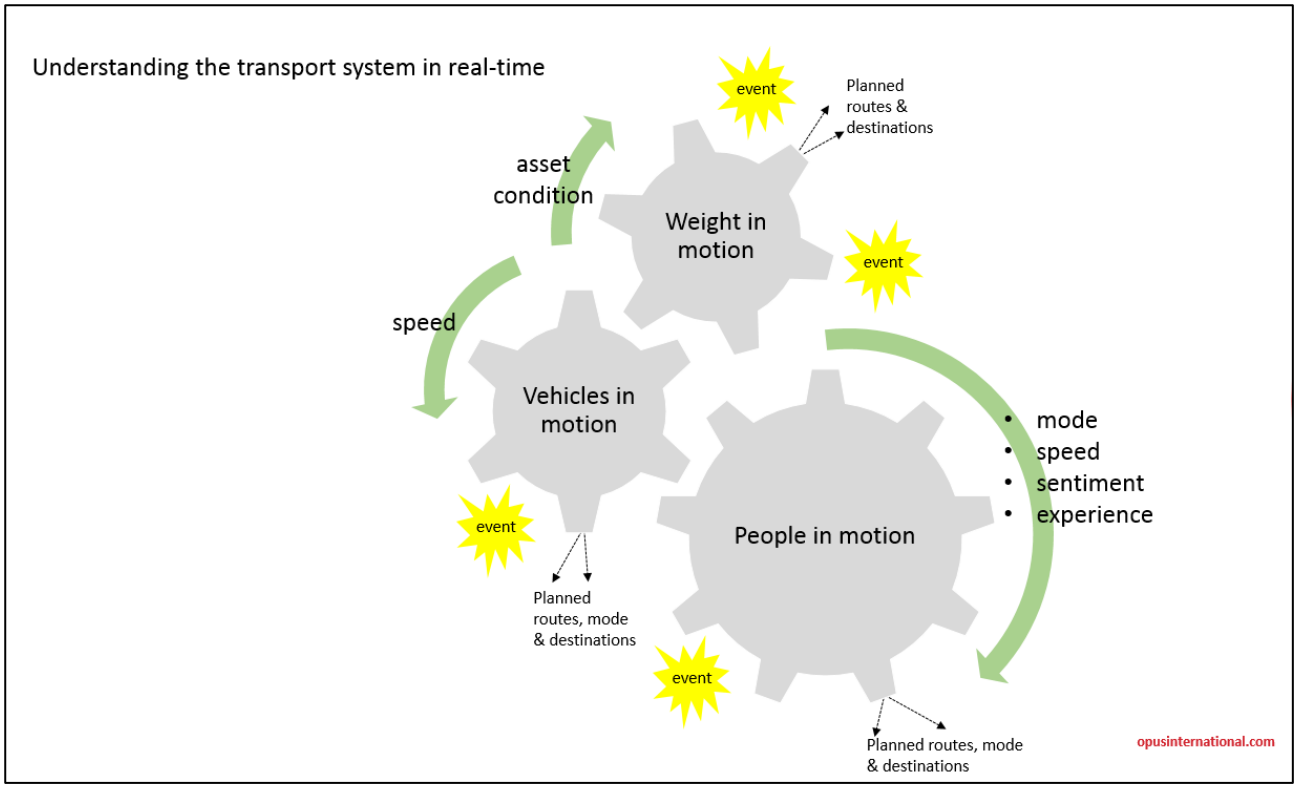
2.2 Infrastructure as a Service

'Infrastructure as a service' (IaaS) is a term that is gaining in popularity in the transport sector to describe new models for taxing/ charging road users as they use infrastructure, taking into account the type of vehicle, weight, time of travel etc.

Essentially, IaaS is a model for charging users for their use of infrastructure. It will bring together congestion pricing, electronic Road User Charging (eRUC) and weight-based charging for heavy commercial vehicles. It could overlap with MaaS in places too, e.g. charging for parking or truck/ coach layovers or stops according to use. IaaS may be borrowing from MaaS's trendy identity and hype, but it should offer a fairer tax system for road users and, for commuters, could encourage more off-peak driving to spread demand and reduce queuing (demand management). IaaS is also a tool for encouraging travel behaviour change, for example on some tolls in Europe, smart infrastructure is able to detect carpoolers and wave their tolls, and perhaps we can expect connected vehicles to have 'people-in-motion' sensors that will interact with charging systems, support the policing of HOV lanes, geofenced ridesharing services and, when combined with traffic flow data, tell us how efficiently we're using our transport assets.

Charging for use of infrastructure is necessary not only as the population grows and demand increases but also because new models are needed to collect taxes as fuel-tax revenue at the pump falls due to increases in vehicle efficiency and as more consumers choose electric vehicles. New Zealand increased the on-road heavy vehicle weight limit to 60 tonnes in 2010, the vehicles approved to carry this weight are taxed accordingly often using NZ's eRUC system. IaaS would change this to allow HPMV's to pay per km according to the weight actually on board, deriving this data from axel-mounted 'weigh-in-motion' sensors. Buses and coaches are keen to tap in to similar changes.

Data collected through IaaS will inform asset management decisions and transport planning for the city's future.



2.3 Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and Vehicle-to-Everything (V2X) communication

Our use of ITS is moving to a cooperative system (C-ITS) in which vehicles and infrastructure will be able to communicate directly with each other. Thus, the overarching systems controlling networks, vehicle fleets, public and private transport services, and journey planning (among others) will be continually 'learning' from information provided across a range of sources.

Existing ITS infrastructure is already utilised in this manner, however vehicles and people are largely excluded from this system now. We do see the value of including vehicle provided information via products such as mapping applications that provide users with near-to-real time journey times and planning based on real world traffic conditions. The current challenge for owners and operators of the transport network is that this increasingly valuable information that would enable them to manage the transport system more efficiently lies largely in the hands of private organisations.

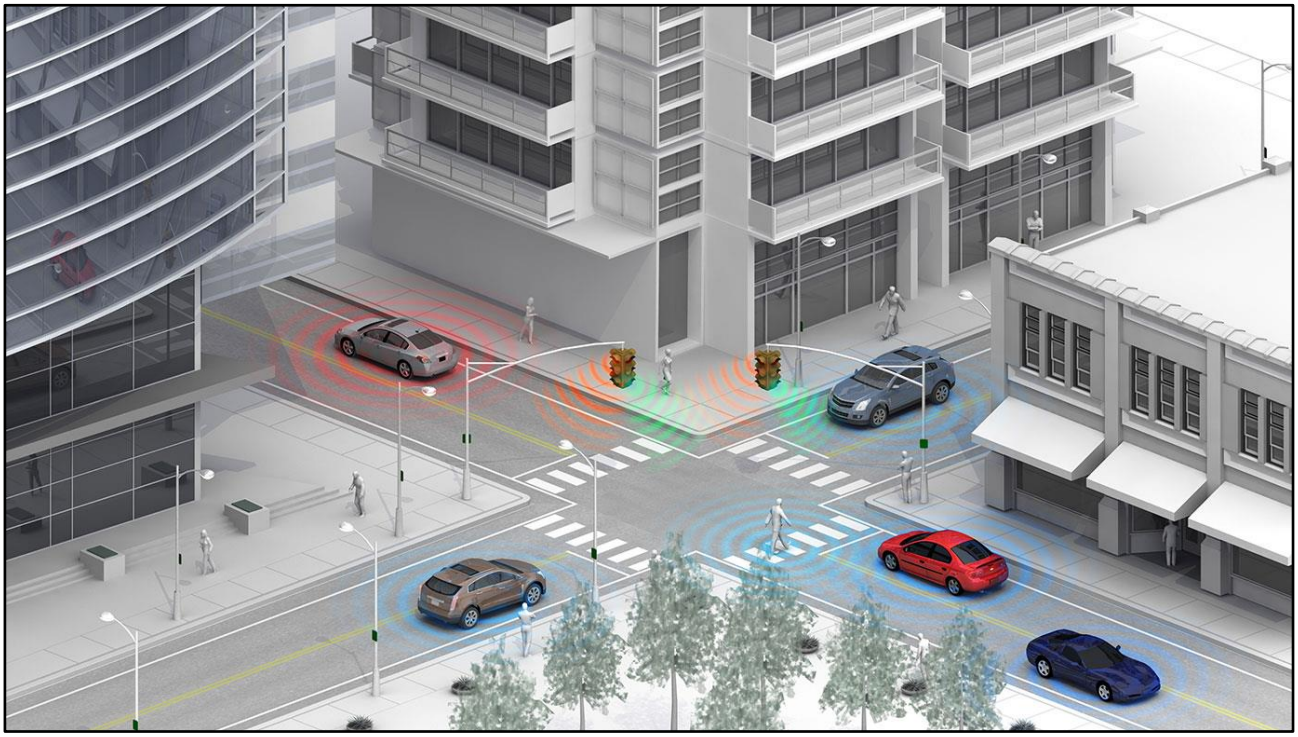


Figure 2-3: V2X scenario with vehicles, pedestrian and infrastructure communicating and sharing information (http://gpsworld.com/transportationroadroad-talk-11142/)

V2V and V2I communications are an important step forward in combining information from a range of sources for better management of the network, this integration is two away and will also provide private companies to improve their service to customers. V2V is necessary for increased automation of driving, vehicles will be 'aware' of other vehicles around them and use this information for lane changing, adaptive cruise control, braking, and immediate response to incidents/threats. V2I expands this to improved traffic management by allowing roadside infrastructure, such as traffic lights and signs, to communicate with vehicles and allow them to respond in real time. Network operators will be able to understand real time demand the need to respond to avoid bottlenecks and incidents, customers (drivers, public transport, freight, emergency services, other private operators) can in turn receive personalised information to keep them informed of their trip and any relevant information they should be made aware of ahead of their arrival at a destination. In turn, network operations can become more adaptive and effective at managing demand for travel within the capacity of the network and smooth trips across multiple routes to provide an overall benefit for movement of people and goods at any point in time.

V2X is the expansion of communications from vehicles to other users and infrastructure including pedestrians, cyclists, devices, and electricity grids. A lot of development is required to achieve this integration however current investment in infrastructure (such as EV charging points) should begin to consider how the data system can begin to include non-traditional sources of data and be future proofed for a time when it becomes feasible to communicate across utilities and modes and between public and private organisations. Vehicle to pedestrian and cyclist communication are important for safety as we shift toward semi- and fully-autonomous vehicles and begin to expect people and intelligent machines to coexist in the same urban spaces including dense city centres.

V2V communication will be largely for real-time decision making in vehicles and are focused on collision avoidance with other vehicles and objects on the road. V2V technologies also require all, or most, other vehicles on the road to be connected otherwise non-communicating vehicles cannot

be 'seen' without supporting sensors such as radar and LiDAR. Alternatively, V2I communications are geared toward broader traffic network management (such as adaptive vehicle speeds to match phasing of traffic signals along a route to maximise fuel economy and network flows). These communications are more focused on longer-term data analysis enabling complex insights across a wide range of network elements to be developed. This requires significant computing power and the ability to store large volumes of data over time. V2I applications and technologies are likely to be available and in use before V2V becomes widespread enough to be most useful. This creates an opportunity for infrastructure owners and managers to lead the local market in adoption of vehicle communication technologies and put in place the required data systems and analytical capabilities before V2V and V2X become widespread.

There remain major challenges to successfully implementing V2V, V2I and V2X infrastructure and data systems. One of these is agreement between automotive manufacturers, infrastructure manufacturers and providers, and operators of the data and analytic systems around standards and funding. New Zealand is an importer of its vehicle fleet and so will be guided by overseas decisions, however as identified in the Government's ITS Action Plan international jurisdictions in Japan, Europe and the US are all proposing different radio frequencies to carry out communications.

There will also be significant costs for establishing, maintaining and upgrading physical infrastructure on the network. Given that the benefits will be shared across public and private organisations it is unclear what the model for future funding and ownership will be. Any system must be 'future-proofed' for changes in technology and able to be upgraded or modified without the need to replace entire assets, plug in and go type infrastructure for lamp posts is already available for a wide range of sensors to be plugged into an on-site processing unit. This should be the preferred investment approach for ITS infrastructure moving forward where possible.

The first question to be addressed is what is the tipping point/starting point for investment in these technologies? Taking the Bluetooth sensors on Wellington's road network as an example, a certain number of devices in vehicles are needed for roadside sensors useful for tracking vehicle traffic. Infrastructure capable of connecting with and sharing information between vehicles and people on the network will carry a significant investment and there is a balance to be struck between investing at a time when enough capable vehicles are on the network, but not too late that opportunities to innovate alongside vehicle manufacturers are missed. Going back to the Bluetooth example, if new V2I infrastructure replaces Bluetooth technologies and makes these sensors obsolete, how can we future-proof new sensor networks to be more adaptable to change?

V2V, V2I and V2X technologies are enablers of other technology trends discussed in this document, particularly for network operations and the introduction of autonomous vehicles on Wellington's roads.

Dashboard Insights. *Vehicle-to-Infrastructure Technologies.*
https://www.autoindustrylawblog.com/2016/02/11/vehicle-to-infrastructure-technologies/

2.4 Network operations

Information is increasingly being collected from a range of sources, some of this is accessible by network managing authorities however much of it is collected and held by private third party organisations. Not all of this information is informative for daily management of Wellington's network and transport services however integration of selected key data sources will provide for robust analytics and insights that will benefit asset and network performance.

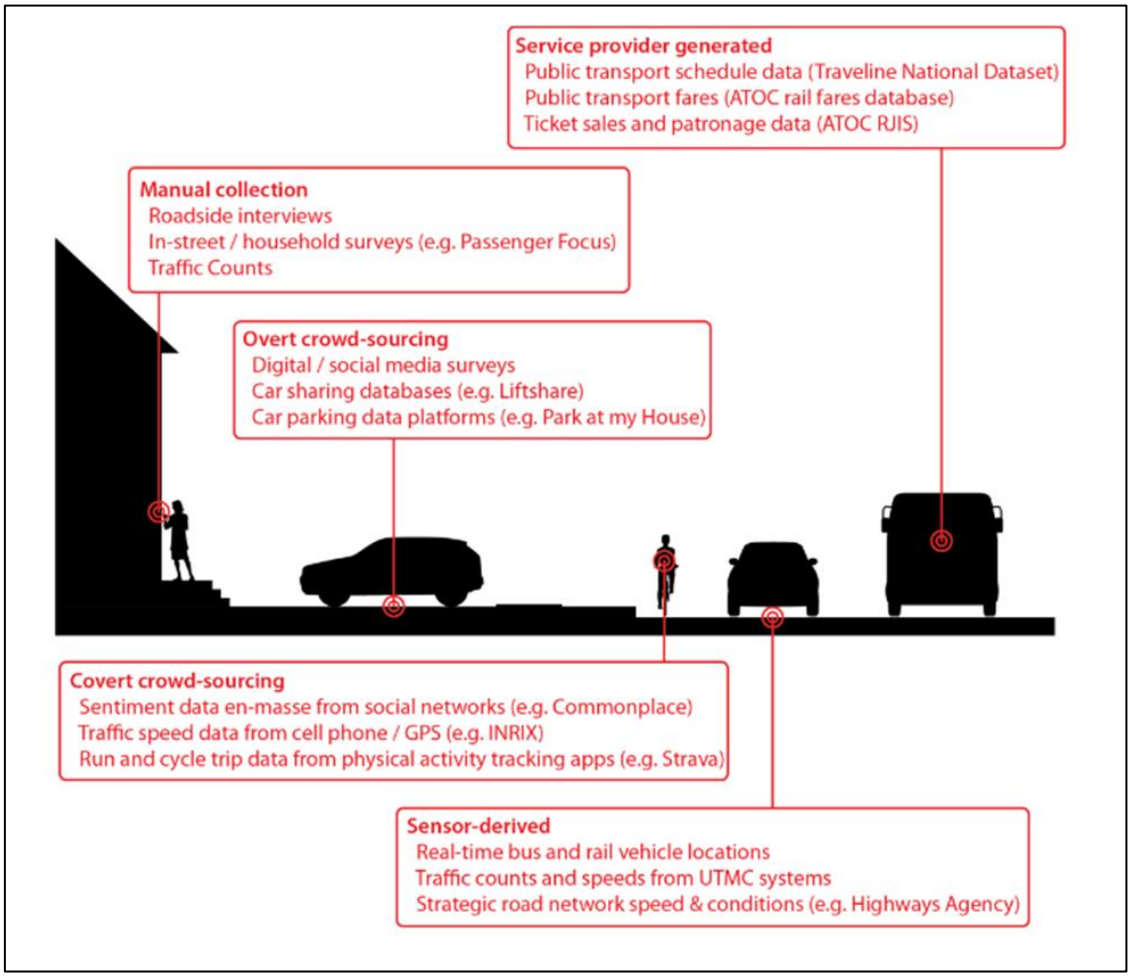


Figure 2-4: Sources of intelligent mobility information (https://ts.catapult.org.uk/wp-content/uploads/2016/04/The-Transport-Data-Revolution.pdf#page=35&zoom=auto,-58,460)

2.4.1 Intelligent network management

Wellington's transport network operations are becoming increasingly mature, investment in infrastructure such as the Smart Motorway signals a shift toward real-time automation of vehicle traffic on major roads for improved reliability, safety and flows. This 'intelligent network management' relies on multi-sources of information from vehicles, people and assets to understand how the network is being used in real-time. Combined with data analytics that turn large volumes of data into usable information and knowledge the automated system can respond to demand and incidents dynamically to better manage the movement of people and goods through the network. Ownership/responsibility of such a system is an important and yet undefined factor. The region's road network is operated and managed by a variety of organisations so shifting to an integrated data model requires clear governance structures that meet the needs of all groups.

As the capability to process information in real-time improves in our network management and operations centres, and the sources of usable information that are integrated in a single platform increases, the Smart Motorway approach will extend to other corridors across the transport network. It is likely that State Highways, major arterial and commuter corridors will be the primary focus of real-time automation of network management.

Other forms of intelligent network management such as adaptive traffic light control systems that manage traffic based on real-time demand, as opposed to traditional phasing approaches that are set based on historical modelling, will need to be implemented at a city level to be effective. Automated control systems have the potential to priorities certain movements such as public transport and freight, so an understanding of the data requirements of such a system and how information from private suppliers must be explored ahead of time to address challenges.

2.4.2 ITS infrastructure

Wellington's road transport network has made use of sensors to collect data about network use for network management and investment decision making for some time. A primary example of this is the series of Bluetooth sensors on the State Highway Network that collect information about the number of vehicles on the network, and travel time between points. These technologies capture information from a relatively small number of vehicles in the overall fleet moving on the region's roads at a given point in time but still provide valuable insights for real-time demand and performance.

The cost of such sensors is reducing while our ability to process the information they provide for insights is increasing making it cost-effective to increase the coverage of sensors on the network (for example Wellington City's Bluetooth monitoring network). There are risks associated with such an approach, Bluetooth gateways rely on people travelling with cell phones that have their Bluetooth function turned on passing through them to record information. A change in technology away from Bluetooth to another form of wireless technology has the potential to reduce the rate of data capture to zero.

Video footage is an emerging field of innovation for network management, CCTV footage has been used for some time to provide network operators with a real-time view of what is happening on certain segments of the network. Now the use of machine learning techniques video footage is able to be used for real-time identification of vehicles, cyclists and people, classification of vehicles by type, and tracking of movements through a set space – particularly useful for monitoring of intersections where a large number of vehicles and people pass through the same space (NEC is currently applying this approach in Wellington at the intersection of Taranaki Street and Courtenay Place).

VMS signs are also in use on Wellington's roads to communicate predicted travel times to travellers and provide updates on incidents and planned events impacting the network. These sources of information provide travellers on the network with information about their journey but do not inform ahead of time for journey planning purposes. There are multiple sources of this type of journey planning information, described below, however not all are integrated with information about the network itself (e.g. road works, incidents, events) and instead are based on historical and real-time measurement of traffic flows to predict journeys. Better integration of asset related information into journey planning and VMS communication tools will improve the service for users.

Key to these technologies is a system that is resilient to future technology development and the decline of existing technology. There are many 'off-the-shelf' solutions and products being presented to the sector, taking advantage of these as they emerge is a cost-effective alternative to investing large amounts of money in infrastructure that may become obsolete at a cost to Council and Government organisations. There are downsides to such a commercial model, primarily in ownership of information and the ability to drive innovation internally to meet the needs and

vision of network operators. The question also arises of how these future systems will be governed – a human-centred approach or fully automated. At the moment many automated systems are first implemented with human control, this enables the system to be 'taught' while also learning and customising the system along the way (for example Wellington's Smart Motorway).

2.4.3 Third party sources of information

Perhaps the greatest shift being experienced by the transportation sector internationally is the emergence of 'non-traditional' sources of information that have significant value for the sector. Google, initially an online search engine and advertising company, has emerged as one of the world's most significant owners of location based information and journey planning. Many other data and mobility service companies are working in this space as well, from credit card companies who can provide spending insights as people move around the city (e.g. Mastercard) to cell phone providers who have created an in-depth understanding of where their customers live, work and visit by time of day to a relatively high level of accuracy (Qrious). Microsoft, Apple and Uber are all major international companies who will be important for the future of intelligent mobility in New Zealand and Wellington. Alongside these large corporates is the 'open' movement with organisations such as OpenStreetMap providing data and mobility services based on crowd-sourced information that is made publicly available.

The benefit these private organisations have over transport providers operated by local and central authorities is that consumers willingly share a large volume of personal information, often without much consideration, in return for the benefits they are provided with. Google's search engine, mapping and journey planning products are all free to use, while customers of credit card and cell phone companies agree to the collection of private information within agreed terms in return for the use of each company's products and networks.

A major emphasis throughout government is examining how these valuable third party datasets can be used for the management and delivery of transport services in our cities. These are challenging commercial models to establish, but Wellington is perhaps the only city of scale other than Auckland where the benefits of doing so will have a significant social and economic benefit.

More importantly, is preparing for new sources of third party information in the future and ensuring that private parties not become increasingly more informed about the nature of mobility in our cities at the expense of our operation's activities. Connected vehicles, discussed below, present a significant opportunity to bring together public and private information and data systems for the benefit of all parties.

2.4.4 Wellington's network operation opportunities

- Implement real-time traffic management systems that extract value from historical data alongside real-time data capture to manage multi-modal movements of people and goods on the network.
- Trial new ITS infrastructure and off-the-shelf monitoring systems as part of a network wide approach to intelligent network management.
- Integrate limited third party traffic data for routes where sensors are in place to test the validity of integrating multiple sources of data and their use in real-time traffic operations.
- Test adaptive traffic management systems via dynamic signal phasing in response to current network conditions and seek opportunities for priority movement of vehicles on selected corridors.

2.5 Electric vehicle infrastructure

Wellington has previously run an EV car trial (2010-2012) introducing a small number of Mitsubishi i-MiEV vehicles for the public and businesses to use. These vehicles were found to be 'ideal' for most urban transport needs with participants impressed by the power, range and overall comfort.

However, uptake of EVs in New Zealand has been very low to date however there is huge potential nationally given our majority generation of electricity via renewable resources. The provision of a widespread charging network is a fundamental enabler of future electric vehicle fleets. This infrastructure has a comparative advantage to the model of centralised patrol stations where vehicles must travel to a specific point to refuel as individual chargers can be provided on the roadside and in car parking buildings across the city.

Charging units are already installed at some petrol stations in Wellington and the Council is working with commercial partners to install chargers across the city now. Zealandia was the first site for a vehicle and bike charging unit to be installed. The overarching goal of these efforts is to make charging infrastructure visible and provide motorists with confidence that there are many readily available points for them to recharge if needed. PlugShare provides a website mapping EV charge points in New Zealand, including both public charge points and residential locations that it's members are willing to share with others to increase the coverage of the network.

Given the lack of EVs on Wellington's roads an immediate investment in distributed charging infrastructure does not make economic sense. However, there is evidence that demand exists, Wellington's first EV car share service, Mevo, already has a waiting list of people before its launch in December 2016. Investment should be at a rate which allows these services and uptake of private EVs to grow quickly rather than waiting for a high level of demand to justify infrastructure and network planning. Given the likely future (20+ years) vision of fully autonomous electric vehicles is it important to plan for this infrastructure now to proactively meet demand and avoid a reactionary approach.

There are implications and challenges that must be addressed beyond the investment in charging units alone, including:

- Regulatory considerations of installation of electric charging units adjacent to the roadway.
- Electricity network infrastructure improvements, some fast charging units must be connected directly to the main power grid.
- Changes to how power is consumed as private EVs are charged overnight via a domestic socket.

EVs will see uptake in public transport and freight fleets also, there is a large expense associated with completely replacing a regional bus network with electric vehicles however upgrading as individual vehicles reach the end of their life is likely to become an attractive option over time as the cost of technology decreases and batteries improve.

Wellington utilises electric trolleybuses, powered by overhead lines, on some routes in the central city – though the decommissioning of this system is being dicussed. This form of electric power in the fleet is scheduled to end with a preference for existing trolleybuses to be retrofitted with electric drivetrains and rechargeable batteries. The major benefit of this transition is buses will no longer be constrained by operating only on routes with overhead wires providing a greater level of flexibility and resilience.

Greater Wellington Regional Council. *How Greater Wellington Regional Council is electrifying its vehicle fleet*. http://www.gw.govt.nz/assets/Climate-change/GWRCelectric-vehicle-policy-2016.pdf

http://www.plugshare.com

2.5.1 Wellington's electric vehicle opportunities

- Continue to form public-private partnerships with energy companies and commercial organisations to install a basic public charging network in Wellington.
- Look to other areas and local case study 'champions' for guidance on assisting commercial organisations with a transition to partial or fully EV fleets as practical.
- Work with EV car sharing groups to create a 'free flowing' system where users can pick up and drop off from multiple points around the city as opposed to returning a vehicle to the initial location.
- Identify locations where kerbside parking can be retrofitted to provide fast charging units on central city streets to raise the visibility of these units.
- Continue to lead New Zealand with the use of electric vehicles on public transport routes and continue to look for opportunities to expand the numbers and network coverage of buses as current stock is replaced.

2.6 Semi- and Fully-Autonomous Vehicles

The development of autonomous vehicle technologies is perhaps the most discussed future technology expected to revolutionise the way we move people and goods around our cities. It is important that the public are presented with a broader vision than just the ability to make 'hands-free' free trips in place of their current journeys. From a network management perspective, autonomous vehicles will still travel on congested networks if uptake of autonomous vehicles are not complemented by a change in culture around car ownership and the use of shared and public transport services.

A fully autonomous future for vehicles is several decades away, however early technologies are ready for testing now. In Christchurch, the first trial of a fully autonomous vehicle is soon to be underway on the airport's private roads with a long-term goal of moving onto public roads when the technology has been proven safe and New Zealand's regulatory environment is in place.

When public road trials of autonomous vehicles alongside human driven vehicles become viable Wellington, should be ready to provide some of its network for testing. Learnings from the early trials in Christchurch will be important but also understanding what may be required from a network perspective to ensure that infrastructure is up to standard. Opportunities within the public transport network would include trailing a fully autonomous bus/shuttle to run an inner-city route. Autonomous vehicles will play an important future role in solving the 'last mile problem' in suburbs through a demand responsive service that collects people from their homes to transport them to public transport stops and stations for onward movement.

Autonomous, and driverless, single deck trains are coming soon to Sydney's (2019) Northwest line of their city rail network, similar trials/technology could be investigated for feasibility on the Wellington region's rail network.

Converting to an autonomous fleet and readying infrastructure for this transformation is still high risk and expensive at this point in time. There are many millions (or perhaps billions) of kilometres to be driven and analysed to demonstrated these vehicles reliability in terms of fatalities and injuries. For example, there is one death per 400 million kilometres driven on Auckland's motorways so to prove a benefit in terms of safety a lot of testing and data is required. The benefits for traffic flows are valid, however a fully autonomous fleet is decades away and has a long lead-in time with mixed human and autonomous drivers sharing the road when these benefits will not be felt. Wellington does not have 20-30 years to wait for an autonomous fleet to 'solve' it's congestion issues.

The introduction of autonomous vehicles will be led by the automotive industry within standards and regulations set by central government. Wellington's authorities will play an important role in facilitating the introduction of these vehicles into the public transport fleet, including a potential shift to demand responsive public transport, and in assisting car sharing services or private on-demand transport providers to include these vehicles in their fleet in a way that complements the public transport system rather than directly competing with it. These initiatives should be a part of a national push for early adoption and testing of technology with local transport authorities and central government working together to import and provide autonomous vehicles in a cohesive manner that facilitates sharing of information and learning across regions.

3 Influencing trends

Alongside technologies that have a direct application to transport network, there are a number of established and emerging trends that are likely to have an impact on transport networks over the medium to long term. These include:

- On-demand goods
- Remote working
- The on-demand / gig economy
- The sharing economy.

3.1 On-demand goods

As long as people have lived in towns and cities, the way we access goods has been to walk, drive, bike, bus, or train to a distribution hub e.g. a butchers, grocers, or supermarket for food. These decentralised nodes have been the end point in the supply chain for all goods from essentials to luxury items. The distribution of theses goods over the last-mile to our homes has been the responsibility of the consumer. However, over the past two decades this has been changing and the way we access goods is becoming more akin to the way we access services i.e. they come to us when and where we need them. There are two key changes underway:

- Suppliers of goods that were not previously distributed over the 'last-mile' are making distribution (delivery) services available or are being augmented by delivery services; and,
- Goods for which distribution services are already established (largely intangible products like television and music) are moving to on-demand models.

Ultimately it is likely that all goods (tangible e.g. food and clothing, and intangible e.g. film, television, and music) will move to on-demand distribution. While it is difficult to predict when on-demand goods will become the norm, some companies have a committed to ambitious timelines e.g. Amazon announcing that they will launch their automated drone delivery service Amazon Prime Air in 2018.

3.2 Remote working

Remote working has been lauded for decades as the trend that will transform our lives. However, the vision of a future where everyone is able to work from the comfort of their own home has not eventuated. This is not only because of the cultural / behavioural change required for firms to adopt this way of working, but because there are in fact benefits related to working together, co-located, in an office and in a large organisation.

Previously these benefits have not been able to be replicated by technology. However, we are now seeing the emergence of the infrastructure (affordable high-speed broadband through the Ultrafast Broadband Network) and tools that are able to replicate the benefits of co-location and working in a large organisation for individuals and geographically distributed teams.

While it is unlikely that remote working will become widespread overnight, the availability of tools is likely to enable a steady increase in the adoption of the practice. Local authorities have already noted the potential of remote working to reduce demand (in particular at peak hour) on the transport network. It is likely that over the medium to long term this practice will start to impact the number, type, and time-of-day of trips.

3.3 The on-demand / gig economy

One of the most significant trends related to work is the rise of the 'on-demand economy' i.e. an economy where workers and clients (employers) use algorithmic matching to connect with work either:

- Where and when work is available or needs to be done; or,
- When they feel like working or need to earn money.

The 'on-demand economy' is not limited to one particular sector, or limited to high or low value jobs. There are a range of apps enabling pragmatic part-time workers supplementing their income, full-time freelancers working across one industry, and dedicated multi-taskers working across industries. Apps that support this include:

- Uber (https://www.uber.com/)
- UpWork (https://www.upwork.com/)
- AirBnB (https://www.airbnb.co.nz/)
- Mechanical Turk (https://www.mturk.com/mturk/welcome)
- TaskRabbit (https://www.taskrabbit.com/)
- Roost (https://www.roost.com/)
- Catalant (https://gocatalant.com/)
- DogVacay (https://dogvacay.com/)

The greatest impact of this is likely to be the redistribution of peak-hour traffic across the day, a reduction in the number of people making one long trip each day and an increase in the number of shorter functional trips across the day.

3.4 The sharing economy

The current state of the sharing economy is one where people share otherwise tradeable goods and services e.g. in the case of Uber, sharing your car and driving services with a stranger for a fee. There has also been a massive success in sharing space for accommodation e.g. AirBnB. In the case of AirBnB the function of the space being shared stays the same. However, as the nature of work changes we are starting to see the need for, and rise of, multi-functional spaces i.e. the changing of the function a space performs over the course of the day. Apps like Hoffice (http://hoffice.nu/en/) allow people who work from home to share their homes as an 'office' for like-minded individuals. As this trend grows there could potentially be an impact where people go and when.

The sharing economy for vehicles has been introduced to Wellington with CityHop currently providing services and new entrant Mevo arriving with a waiting list already on their books. Roam and YourDrive both allow individuals to rent their personal vehicle out to others while it is not in use.

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