

Public Transport 2045: Interview findings

This document summarises views of experts interviewed for the Ministry of Transport's Public Transport 2045 (PT2045) project. More information about this project, along with further publications, is available at:

<http://www.transport.govt.nz/area-of-interest/infrastructure-and-investment/transport-outlook/>

What is the long-term future of public and passenger transport in New Zealand?

The PT2045 project explored this question through 50 in-depth interviews involving individuals with expertise in public and passenger transport. The interviews took place between February and April 2016. They were conducted in several ways – face-to-face, telephone, and via Skype. All interviews were recorded, transcribed, and then returned to the interviewee for assessment.

This document captures the high-level findings from these interviews. Comments from participants have not been attributed to specific individuals. We encouraged interviewees to speak openly by guaranteeing their anonymity.

Please note that numbers in brackets indicate how many respondents agreed with, or made, a statement.

Key themes

Types of public/passenger transport available in 2045

Beginning with a broad overview of the transport system, one common view expressed in the interviews was that the transport system and modes that we have today will still be around in 2045 (15), but there will also be a wider range of modes available. Transport modes that are not currently popular will also become mode prevalent (21). “There will be quite important differences [in 30 years time], and that largely comes from embedded IT being used in, not just *transport* systems but *working* systems, and that includes robots of different sizes. So you could easily have, instead of a pizza delivery car with a student driving around in it, a pizza delivery robot, such as has already been developed, but one that keeps pizzas particularly warm or perhaps even cooks the pizzas on the way. So you will certainly have more autonomous vehicles of various purposes which aren't necessarily driven or even meant to accommodate people at all” (Interview 50).

By 2045, one respondent believes that the key difference in 30 years time will be a change in focus; public transport will be more responsive to people's needs and demands. “The key focus point is that it's going to be more customer focused and fitting people's demands. Technology is helpful, but it will be limited to certain areas (e.g. automation). Being able to pay for public transport wherever you are in the country will exist” (Interview 47).

New forms of transport

Related to this, some respondents thought that there would be few new forms of transport or new ways of delivering services because of the investments that we have made in today's transport options (7). There will still be a lot of personalised transport (6).

Other respondents thought that there would not be completely new forms of transport but rather different ways of doing the things that we are already doing, such as autonomous vehicles, guided buses, increased internet brokerage of transport or demand driven transport and Mobility as a Service (MaaS) (14), or new forms of transport at the margins, such as magnetic levitation or monorails (1). It was suggested that a significant amount of experimentation and innovation will be used to trial different methods to meet the needs of different demographic groups, such as the elderly or disabled (1).

Another possibility was the introduction of economic incentives to affect mode choice (1). An international public transport expert related this to a recent UITP (an international public transport firm) survey: "it's striking, from the recent UITP survey, that a lot of metro systems, when they need to re-equip signalling, rolling stock and so on, find automation is attractive because they're only looking at the incremental costs of slightly more complex signalling. A lot of the renewal expenditure would arise anyway" (Interview 12).

Changing relationship between public and private transport

Alternatively, there would simply be a changing relationship between public and personal or passenger modes (7). This includes an improvement in the public perception of public transport (14); "public transport will be considered cool, rather than not" (Interview 48). Some took this further by saying autonomous and electric vehicles will have replaced many of the current vehicle types by 2045 (14).

On the convergence between public and personal or passenger transport, it was acknowledged that the cost of travelling by different modes may have some influence on how vehicles are used, and perceived – automation will be the impetus for this change. "At the moment, drivers cost around 40%, 50% of public transport and taxi operations. So, if you can get rid of a driver for 40%, suddenly you have basically an affordable taxi. The reason that taxis are not used even more than they are already is because they're expensive on a per trip basis. But, if you're reducing the cost of providing that per trip basis vehicle, then the costs come down and that option suddenly becomes a lot more attractive; this is particularly for groups of people or for trips that are quite complicated to make by a traditional kind of a public transport alternative" (Interview 49).

Small personal transportation modes, such as hoverboards, skateboards and Segways, etc. will also have a place due to their efficiency and affordability (1). These personal transport methods could expand to include jetpacks, small helicopters, or another form of small drone (2). This may not be 30 years away, but could be in the works; we might see it in 50 years (1).

One respondent highlighted the relationship between these new forms of transport and income: "yes, there will be new forms of transport and new ways of delivering transport. But, ownership of that transport will start to depend on the ability of people to participate in the economy and their competitiveness vis-à-vis the other forms of intelligent life which may not be human" (Interview 50).

It was not a one sided conversation though. There were respondents with the belief that traditional public transport will remain important. There were a range of reasons for this view, including infrastructure limitations, the economics of moving mass numbers of people at once and the real cost to the consumer for choosing one option over another (3). “There are some people claiming that automated and driverless vehicles will render public transport a thing of the past but you still have a finite amount of road space and it’s still going to be more expensive to hop into a driverless car than it will be to get on a bus. Public transport will remain very important because of the economics of shifting large numbers of people” (Interview 41).

One respondent felt that in 30 years time we could begin to see the use of flying cars or small-automated helicopters. However private transport would still be primarily on wheels (1).

Active Modes

Walking and cycling will still exist, though the level of their relative popularity is less clear. Some thought active modes will become more popular (8) due to:

- supporting technology (such as e-bikes), infrastructure (such as a dedicated cycleway etc.) or business models (such as car-sharing) (4)
- increasing urbanisation and higher cost of transport (2)
- the safer and more pleasant environment afforded by autonomous cars (1)
- a greater focus on health (2)
- conventional transport networks becoming immobile and less efficient with increasing volumes of people and demand (1).

On the other hand, there were concerns that the popularity of active modes will be challenged through more dispersed trip patterns (2) and the possibility of the “bus stop coming to them” (Interview 11). Policy measures will need to be in place to push the growth of active modes (1).

Local conditions

One crucial element regarding the types of public/passenger transport noted was the importance of local conditions (8), including the type of land use (1) and local regulation (1). The differences between urban areas with high population densities and rural areas or suburban areas with low population density, for example, means that urban areas would still see high frequency mass transit services on selected corridors. Less well-served routes, that currently operate with lower frequencies, would be replaced by mobility service type options, or smaller vehicles (6). “Local transport in an urban sense will be a city-based system, whereas in a rural areas it might imply more than just a short move, it might also be a connection to the nearest major settlement” (Interview 11).

Offering a slightly different perspective, one respondent suggested that intense competition for the limited amount of available space in cities will restrict the development of new modes. This is because growing modes (e.g. cycling and public transport in London) tend to ‘win’ space from less popular/effective modes (e.g. the car in London) (1). One commentator suggested that because there will be a huge amount of vehicles competing for public space and the transport corridors, those corridors will be diverse and flexible to accommodate different types of transport (1).

On-demand

Regarding the types of public/passenger transport that we will see in 2045, the dominant theme was that we will see a rise in on-demand services. This will facilitate the move to different types of transport and different ways of doing things. Many respondents believed the rise of on-demand transport would challenge existing transport options (3) leading to a convergence between public and private transport (1).

Some believed the move towards demand-responsive transport, particularly outside major public transport corridors, will see traditional buses replaced with on-demand options (8). Others thought the on-demand paradigm will see a greater range of public transport from small, shared vehicles, to mid-sized vehicles and larger vehicles for peak demand (3). Shared private vehicles could also provide massive productivity gains (including the removal of subsidies) by transitioning low-frequency, low-density, suburban markets to shared services (1) for moving people and freight (1).

One respondent suggested this on-demand travel could be in the form of an automated 'pod'.
"Instead of cars you could have essentially automated vehicles which could be like pods of some sort. These pods may well be sort of publically available. So you'd rent a pod, dial a pod, if you like, and it would come collect you and take you to where you want to go. I think that's potentially feasible. A sort of a driverless automated universally available taxi service, if you like" (Interview 49).

On-demand transport was seen as working in conjunction with traditional high capacity, corridor public transport (5). There could be three levels of service:

- mass transit to get large volumes of people to a destination, particularly as work habits are unlikely to significantly change (3)
- smaller services around the suburbs, such as mini-buses (1)
- smaller, on-demand or similar modes to transport people to the main corridors (1)
- personalised on-demand services such as Uber-type sharing or task-sharing type services where there would be a higher cost, but a premium service that is individualised and flexible (4).

Attitudes to car ownership

There was some uncertainty to how attitudes to ownership will play out.

"The attitudes in terms of vehicle ownership is going to be a fascinating question because again the onset of things like autonomous or semi-autonomous vehicles is going to create all sorts of opportunities for things that we might not even consider. I'm thinking things like greater interest in things like car clubs and stuff where multiple persons could be aligned and sharing a vehicle or alternatively at the family level or household level we may see greater use of motor vehicles because of the flexibility that automation provides" (Interview 35).

However, we also saw some clear expectations in the interviews.

Car ownership will remain

On the question of ownership, several respondents were adamant that individual car ownership would remain of key importance. They suggested that there is no sign of people, especially those who are more wealthy, losing their perception of cars as a status symbol; vehicles will remain a

statement of personality, character, affluence and status (2). Those who are financially better-off will continue to have cars (3), and will continue to spend considerable sums of money on transport. They will be able to travel when and where they want to because they will have the ability to pay a premium for travelling at peak times, and on congested roads. Meanwhile, lower socioeconomic groups will need to use public transport, and may be forced to travel at less expensive times therefore, spreading the peak (1).

An international transport expert disagreed with many others in his field, claiming that vehicle ownership will remain in 30 years time. “I don't think we are seeing a shift in attitudes towards vehicle ownership today, I know that other observers in this area believe that we might be, I'm not convinced that we are, as I'm equally not convinced that we will see attitudes towards vehicle ownership shift in the next 30 years to 2045. What I think we have seen is a shift in the economic power that enables vehicle ownership, that's unambiguous. Attitudes towards vehicle ownership, control, design, to have power over ones mobility, insurance and the ability to be sure that we can get somewhere on short notice etc. – these are the things that vehicle ownership provides that even vehicle sharing doesn't provide as well; so I'm not really convinced that those attitudes will shift, but I do believe that technologies will change” (Interview 9).

Referring specifically to the ownership of private autonomous vehicles, there will be a high degree of private ownership for two reasons: a high degree of status and comfort in owning a private vehicle will remain; and the automobile industry will not tolerate one automated vehicle replacing the need for 8 or 9 conventional vehicles (1).

Some other reasons given for car ownership remaining high included:

- services like car sharing won't allow us to get somewhere at short notice (1)
- New Zealand is still developing dispersed land use, it is building out rather than up, and so people will remain dependant on their own personal travel modes in 2045 (2)
- vehicle ownership has symbolic and psychological meaning, which may make it difficult for some people to give up their ownership (1)
- there are little barriers to car ownership in New Zealand (1).
- private recreational travel dominates both vehicle choice and ownership, which means that we buy vehicles for recreation, not commuting. So, unless recreation patterns change vehicle ownership will remain high (2).

When discussing the impact of recreational travel, one respondent commented: “I am fond of quoting from Vince Dravitzki at Opus, that private recreational travel dominates vehicle choice, and ownership patterns. We don't buy vehicles to drive to work, we buy vehicles to use them for recreation and then we use them for everything else” (Interview 2).

Young people driving/or not

In reference to the current trends concerning the lack of young people obtaining their driver's licence or owning their own vehicle, one commentator suggested that millennials are just responding to economic conditions and are instead simply delaying driving or owning a car, rather than not wanting to own a car (1). “If you're young, all you're doing is you're delaying a relatively high purchase item. So beforehand your status symbol was your car; today it is your iPhone. And to

be quite honest, there's not a lot of difference in cost now between your iPhone and your first car. Once you move into family you have no option and I don't see how that's going to change in the next 30 years" (Interview 48).

Once again, the importance of local conditions came through when discussing ownership: car ownership will differ between urban and rural areas. People in cities are already renting a car for specific purposes, and would rather not own a car due to the high cost of maintenance, such as insurance (1). Those in urban areas will be more interested in having flexible travel options and being able to spend their money in other ways (1). An increase in communal, car-sharing activities will lead to a decrease in the perception that a personal or family car is necessary (1).

Suburban/rural areas

In suburban and rural areas, the ownership model will probably still stick (3), because in low density areas the vehicles will take longer to reach them, and will not be as convenient as owning a car (2). Moreover, cars will be cheap enough to buy, and people in these areas will prefer to buy a car if there is no clear benefit from renting one (1).

Reduced car ownership

Some respondents suggested a move in suburban areas to reduced vehicle ownership, primarily related to the high cost of vehicle ownership. One respondent suggested there will be less vehicle ownership but families will still likely own at least one vehicle; but maybe the prevalence of families owning two or three because of necessity will disappear (4). Coupled with this, one respondent thought "three changes in technology would bring about a reduction in car ownership:

- autonomous vehicles
- electric vehicles
- smart payment technology via sensors" (Interview 24).

The respondent suggests that if you take the driver out of the taxi or bus, which is probably 30-40% of the cost, instantly the cost of the taxi collapses. If you take the internal combustion engine out of a taxi, which is probably 70-80% of the running cost of the vehicle, it's running costs will collapse again (1). Therefore, the costs of running a car / bus service would be very low. The respondent suggests the convenience and price ratio would begin to outweigh the value in car ownership (1).

Other reasons highlighted for reduced vehicle ownership included:

- there will be much more fragmentation in all modes, both public and private, to the point that private ownership becomes non-existent (1)
- autonomous vehicles and the response to climate change will facilitate the move away from private vehicle ownership (1)
- younger people's attitudes to ownership is already changing and this will continue as public transport becomes easier to access (2)
- public transport systems will become increasingly accessible (1)
- vehicle ownership will be economically burdensome, particularly for two key groups: the elderly and the young (1)
- negative externalities of private vehicle travel, such as environmental damage and road deaths, will reduce the desire to own a vehicle (2)

- people will eventually realise that the car not being utilised 90% of it's life is an economic waste (1)
- the car as a status symbol is no longer going to be true (3). Car ownership will become more of a premium, primarily for recreation – although this could be done through hiring a vehicle from a pool (1); car ownership may only be a luxury for the well off (1)
- we will utilise the use of vehicles across people better (2).

The impact of MaaS and car sharing schemes

There was a dominant theme that the availability of Mobility-as-a-Service (MaaS) and car sharing schemes/clubs will make unnecessary to own a vehicle (16), or at least will result in a reduced need to own a vehicle (6). In lower density areas this could mean owning one car, and hiring a second when required (3). Operators may also no longer own vehicles, but instead lease them, or have pooled vehicles (1).

There was another view of what MaaS actually involves. One respondent felt that referring to transport as a form of consumption was incorrect (1). What may, however, fit under the MaaS definition are situations where the consumer purchases an experience that includes some form of transport (1). For example, a consumer may buy theatre tickets that include free transport to the event. Although the transport cost is likely to be included in the initial cost of the tickets, this idea of a package may constitute MaaS (1).

One respondent suggested that this will depend on the recovery from the long global economic downtime that we have experienced. *“If this downtime continues to put pressure on public finances, then funding for public transport may suffer. This may have a flow on effect in encouraging deregulation to allow innovation from companies such as Uber”* (Interview 10).

Hire/lease schemes + Car sharing

On similar lines, there was a suggestion that accessing personal transport vehicles could vary considerably thanks to new forms of hire and lease car schemes made available from the financial and the transport sectors (2). Cars will be seen as an asset to generate income from (1).

One person suggested that the sharing economy, in all its different guises, is not specific to transport. Instead it is simply a strengthening social shift that is having a strong impact on the transport sector. This respondent sees a growing scope to 2045 for cheaper, and often shared, taxi-like services – they work well with human nature, without the need for regulation or information services.

Sharing will also permeate other transport modes and it will become so easy and affordable to access shared transport that there will be little need to own a vehicle (3). When having convenient access to a vehicle matches the convenience of owning a vehicle, there will be a reduced want to own a vehicle (1).

It was noted by one respondent that because human responses and behaviours are so complex, it is difficult to foresee how ownership levels will change in the future. *“Attitudes to ownership are*

complex, as we know, so maybe some people will still want to own their [transport], or they will just hire their transport when they need it” (Interview 49).

The transition from today to 2025

In terms of the transition between 2016 and 2045, some commentators pointed to specific developments that could profoundly shape the transport system, while others highlighted that transition could occur from anywhere. The transition could be facilitated by new technologies – such as driverless vehicles, intelligent buses or trains – or by demand-driven changes such as the structure of workdays, leisure activities, and the use of space or land use patterns (1). It could also be driven by external shocks (2).

Technological developments

The development of technology was seen as being crucial to the speed of the transition. The role of experimentation with technologies also generated interest (2). However, some respondents suggested that the transition will be very messy, particularly as vehicle manufacturers and regulators try to deal with the challenges of autonomous vehicles (3). One commentator discussed research that suggests the transition to autonomous vehicles will be much slower and gradual than current thinking due to significant steps needed in the regulatory and insurance space. An example is determining how to programme autonomous vehicles to behave if a child steps out onto the road; does the vehicle choose to save the passengers in the vehicle or the child (1)? Likewise, how do two autonomous cars, coming towards each other, interact on a narrow street with cars parked on both sides – are they just going to sit there (1)?

One participant highlighted the lifecycle of vehicles as an important factor in determining the speed of developments. “In terms of the transition, one important factor is vehicle lifespan. For example, the lifespan of buses and most other road vehicles we’re looking at is maybe fifteen years, so that means by 2045 you’ll have had possibly two replacement cycles of the existing fleet. That makes it easier to bring in any innovations in terms of alternative fuels, live systems and so on. For rail that’s a much longer time period, it’s about one generation rolling stock, and longer still in respect of infrastructure, so the transition I think is dependent partly on this vehicle life and other asset replacement cycles” (Interview 12).

Autonomous

In terms of timeframe, one respondent suggested that during 2045-2050 we should see a fairly high percentage of the fleet as autonomous vehicles, with their uptake taking off in 2030-2035 (1). This process will begin with public transport, such as buses and trains, before moving to taxis and passenger transport; this is because there are various commercial advantages to removing the driver from these modes (5). Another respondent was more optimistic, stating that users will be able to buy high end autonomous vehicles by about 2020 and that new, manually driven cars will not be sold after 2030, with manually driven vehicles being phased out by 2040 (1). Facilitating this process, manually driven cars will be incrementally prevented from accessing parts of the road network; particular lanes or areas will be ceded to autonomous vehicles.

Car owners will also be persuaded to shift to autonomous vehicles due to the lure of lower insurance premiums (1). One respondent added that business and services markets will experience a faster uptake of autonomous vehicles than elsewhere because they are commercially motivated when

buying entire fleets (2). Conversely, it was suggested that as New Zealand is traditionally a technology taker, the transition will be long and slow (1).

“The transition will probably start around 2025, as some automated public transport systems start to come in. By 2035, I would not expect it to be uncommon to see an autonomous bus running along standard routes. The idea that you will have on call public transport, such as the Uber model, is probably going to take a little bit longer because the public will need to accept autonomous vehicles driving off a pre-defined route, but I wouldn’t be surprised to *start* seeing that by 2035. The transition that the Amsterdam people and the Parisians have already started towards, is much smaller buses and more of them. I think this *seems* to be the way things are going, certainly if they can operate in platooned mode, which basically means you can fit more carriages together, as it were, so they effectively operate like a train” (Interview 50).

Public acceptance

Some respondents thought the combination of public opinion and new business models will strongly shape the transition to 2045; public acceptance will determine the success of new technologies (3). However, whether the transition from manual to autonomous vehicles would be managed, or simply left to evolve, was unknown (1). It was also noted that there will be a lot of volatility and variety in business models for public/passenger transport services between now and 2045. Eventually there will be a consolidation period, likely between 2025 and 2035, as people get a better understanding of the marginal and running costs of the vehicles (1).

Public acceptance of shared vehicles, as well as autonomous vehicles, will be an important part of the transition (1). It was suggested that people in places like New Zealand are less likely to share a vehicle with strangers. This “has implications for system capacity, because if people still want privacy (which they will have in a private vehicle or driverless pod) you could still finish up with quite low vehicle occupancies, particularly if autonomous vehicles become more feasible” (Interview 12).

Other key points:

Other key points about the transition:

- the trends will gently evolve (3)
- behaviours and operating models will change faster than technology (2)
- the transition over the next 25 years will involve strengthening the core corridors and networks to allow for faster rail and roads; there needs to be investment to facilitate agglomeration (2)
- it will be too expensive for individuals to purchase autonomous vehicles, they are more likely to be a fleet type service (e.g. UBER) that integrates this technology into our transport system. Over the next 20-30 years most of the regular fleet will be removed (2)
- the market will lead the transition as there are clear economic opportunities for business operators to move into the passenger transport space, but there will be areas/routes that are publicly owned, or fully subsidised, to make sure they are covered. The transition will therefore be responsive to both market demand and market failure, but also increasing social connectivity and the opportunities that that will create, especially through technology and social media (1)

- if the market is left to dictate the pace of change we will have suboptimal outcomes, “they will be driven by the short-term profit focus of companies, rather than the long-term sort of holistic, community-based best outcome that Government might take” (Interview 39).
- from 2016 to 2045 we will see some serious pilots of alternative fuels/methods of propulsion, such as making small city areas electric only zones before expanding (1).
- by 2035 we will have shared electric autonomous vehicles, so people will not have to find a vehicle, the vehicle will find them (1).
- cost signals will be used to persuade people to leave their vehicles (1).

It was also suggested that we are already moving into this transition period – Uber and car-sharing clubs, etc. are already becoming increasingly common in certain niche locations and this will start to become mainstream – especially in high-density areas. We are also seeing employer shuttles and other demand-responsive transport becoming more common. “The process is already happening, and ultimately as soon as automation comes along, which allows you to remove the driver, then the whole system can switch to what is essentially a universal automated taxi which is cheap to the user, provides an excellent quality of service, and yet still is economically viable for the operator to provide” (Interview 49).

New Zealand Context

Several points were made regarding how the transition to a more automated system could play out in a New Zealand context:

- being made up of islands, and having a smaller number of cars than other countries, is an advantage for New Zealand as it is relatively easy to regulate imported vehicles once the benefits of doing so are understood; meaning that they could convert faster than say the United States, or continental Europe, and so experience gains in terms of safety, lower labour costs, etc. (1)
- in Auckland, for example, roads are still being built so while we may not see traffic or usage peaks now, they could come later - when these peaks are reached people will want alternatives, and this will be the key to transition to autonomous, shared vehicles (1)
- pricing will be the key to the transition, particularly in New Zealand where hypothecation is popular. As more vehicles become electric, fuel tax becomes irrelevant and revenue falls, unless distance charging is applied. If it is applied, it becomes easier to create a more complete form of road pricing that considers time of use, emissions and congestion (1). With more information, people will make more informed decisions and modal shifts will become more likely (1)
- Wellington transport infrastructure will not be much different, but we may be spending smarter rather than bigger (1)
- the transition to driverless public transport will depend on how the unions react (1); there is potential for disruption from drivers unions during the transition period (1)
- by 2030, autonomous vehicles will start to become commonplace in New Zealand, but it will take longer to achieve a high prevalence due to our average fleet age (17-30 years) (2).

Urban and rural areas

Urban high capacity/corridor services

Local context was continually referred to as being crucial to the future of public/passenger transport. Many related suggestions centred on density and the requirement for high capacity corridors versus more point-to-point travel in low density contexts. As populations continue to grow globally, high capacity public transport linking major urban centres will remain crucial (1). Within urban areas, it will be less about the capacity of public transport and more about the frequency – people will expect to turn up and go, rather than wait 10 minutes for their transport to arrive (1).

For less frequent services, no one who has a choice will wait; instead, they will take a taxi. These will be less expensive than they currently are as the taxis will be automated and dispatched more efficiently, therefore they will be cheaper to operate (1). Suburban and rural areas will have demand-responsive transport to reflect their cross-suburban or cross-rural travel patterns (2). Active modes, particularly cycling, will also play an important role in these suburban systems (including e-bikes). They are an age-old technology that are still popular and efficient to travel on (1).

It was mentioned that corridor transport services in higher density areas are only a relatively small proportion of the total travel demand (around 20%), and that this proportion is decreasing. Instead, peri-urban and suburban trips occurring at awkward times are growing. These trips require flexible transport modes.

The remaining 80% share is not served well by rigid corridor transport, and never will be, even with smaller buses. There is therefore a need for transport to adapt to 21st century lifestyles and economic needs. In other words, “transport operators need to design services that are appropriate for the majority of trips, rather than trying to alter the behaviour of these travellers to better conform to the operational requirements of the current public transport network” (Interview 8).

Size of public/passenger transport vehicles

Types/sizes to meet demand

There was a consensus that public transport will need to become more intelligent and coordinated to optimise demand and capacity. The mode will adapt depending on necessity (2). This suggests an explosion in the range of new vehicle types and sizes to better suit different types of services and markets (20). There will be an increased possibility of this with automation, as a public transport expert noted: “[automation] might make the economics of smaller public transport vehicles more attractive. At the moment if they are based on using a paid driver you tend to finish up with a high unit cost per passenger trip” which would be significantly lower with automation (Interview 12).

There will be large vehicles for high-density corridors (11) and shared cars with 3-4 seats, or 6-10 seats, or even smaller autonomous feeder vehicles (11) for lower demand areas. “People will be able to order cars on demand, and so will be able to choose the most appropriate type of car for a particular trip – though scheduling these different types will be a challenge” (1).

This range in vehicle size will allow vehicles to move from semi-corridor and semi-scheduled services depending on the time of day and area served. For example, feeder services or low-density, low-demand services may be a mixture of 3-4 passenger autonomous vehicles, or mini-buses with 10 people (5), which could then potentially platoon or even physically join together if necessary (8). This

combination of vehicle size will better serve those who may not have the best access to mobility currently (1). “If you’ve got what we know as the transport disadvantaged, cause you can’t afford your own car, or you can’t afford to go on a bus even, or you’re disabled, or you live out in the sticks somewhere, then actually maybe there will be more choice for you, because there will be different types of vehicle” (Interview 42).

A few different reasons were noted for this variation in size:

- the drive towards a variety of vehicle sizes will be labour costs (1)
- vehicles will be more tailored to specific journey needs and destination (2), dependent on number of passengers, required luggage, desired use of the vehicle whilst travelling (e.g. family time, business meetings, relaxing).

The insides of vehicles could also be flexibly designed to cater for increased capacity in peak hours, and increased comfort in off-peak hours (1). Additionally, if the transport is a personalised pod, then the interior design could be personalised to an individual’s or group’s needs (1).

One size

Although there was general agreement that sizes will vary, some respondents suggested that the majority will be one size. For example, one respondent suggested that we will have smaller, individual transport units, such as individualised pods, that join together as modules (2). Similarly, another respondent saw vehicles with the ability to join, without being individualised (1).

Increase size

Other respondents expressed a different point of view, proposing that public transport modes will seek to increase the size of vehicles across the board where possible, perhaps to meet the demand of rising population levels (3); particularly on core, rapid routes (1). Increases have already happened for buses, whilst solutions are being sought to do the same for rail (2). Linked to this point is the view that high density cities won’t be able to support individual modes, so large ‘people-movers’ will still be the best way to move people around the city (1). While the autonomy of individualised vehicles is attractive, we don’t yet know the costs of running them. One respondent pointed this out, adding that the liability to the manufacturer and firmware or software updates would also add to the cost of these vehicles, making them an unlikely choice over larger vehicles (1). In sparsely populated areas it is also unlikely that individual pods, or ‘robo-taxis’ will be used as the cost will still be too high (1).

However, it was noted by a respondent that there are physical limits in increasing vehicle size, particularly in regards to trains. The platforms are not designed for larger carriages and existing infrastructure may cause capacity constraints (1). Similarly, investments already made in current public transport vehicles and infrastructure mean that they will still be around in 30 years time. Again, this is particularly relevant for rail (4). Any new vehicles we do see will be focussed on utility value, rather than appearance - so there will be a focus on sophisticated technology, rather than good-looking technology. One respondent thought that 3D printing technology will be advanced enough to allow much more flexible vehicles; they will be able to be configured and reconfigured by adding or removing panels. That would give operators the ability to adapt their fleet to demand (1).

Propulsion system/fuel source

Biofuels

The future for propulsion systems was quite varied. Some respondents thought that biofuels will emerge in the next 20 years (3) but using algal sourced-fuel rather than vegetable sources (which conflict with food production objectives) (1).

Hydrogen

There were mixed prospects for hydrogen, with some respondents suggesting hydrogen is an untapped opportunity and could be very influential (3).

“One thing that the world is absolutely awash with at the moment is shale gas and one technology available at the moment is steam reformation, to create hydrogen from gas. If you look at the motor industry and you look at the activities of Toyota, Honda and from the Korean end, Hyundai – they have a very defined R&D investment and commitment to the hydrogen product. And, looking out a little bit further, they don’t seem to be backing off it. So I think Hydrogen has a much bigger role to play then perhaps is being reflected at the moment” (Interview 39).

However, others thought hydrogen has many problems related to poor energy efficiency, storage issues and various technical issues, which will take a long time to be resolved (7).

ICE

The internal combustion engine (ICE) was seen as still being around, particularly as they continue to get more efficient (2). Some respondents believed as long as there is still oil, there will be ICE vehicles, particularly as the price of petrol will plummet as more people move towards electric vehicles – there will be less incentive to move to electric vehicles (2). These issues lead some respondents to suggest hybrids will be very popular (7), particularly for the suburban or rural fleet (1).

Other

Other key points regarding propulsion:

- we will see a lot of experimentation with different powers sources in the next 30 years (2)
- propulsion technologies that can be retrofitted to existing vehicles will have the greatest effect (1)
- there will be a mix of fuels available and tested, but the key change will be less centralisation of the control and supply of fuel – people will be able to create their own fuel, in their own homes (1)
- there are opportunities for adapting technology – i.e. Japanese rail and its levitating magnetics. The Auckland rail fleet is electric, but it is still heavy and, by nature, it is slow. There are opportunities for faster, more energy efficient and quieter technology (1).

Electric

A majority of respondents believe there will be a shift away from fossil fuels (18). Many commentators thought electricity will become most common to power the New Zealand fleet (20), particularly with New Zealand’s major renewable energy sources, such as hydro and geothermal

energy (3). The fact that electricity can be generated in different ways, such as solar, induction or externally charged (4), means that the move to electric will occur faster once the technology is readily available. Availability, price and the availability of any government subsidies for various power sources will be underlying factors in propulsion type (1).

One respondent highlighted the role that manufacturers will play in the speed of uptake of electric vehicles. “I’m quite down on electric vehicles to 2030. I have grave doubts that there’ll be a hell of a lot of them running around, just simply because of inertia - the market’s very slow. But as the manufacturers start to transition, which they will - they’ve told us they will - then you know, it’s kind of inevitable that that’s where it’ll go. And although this country’s going to follow 12 years behind, you know, it’s still going to get there” (Interview 50).

While there is likely to be a diversity of power forms, air quality concerns will eventually drive electric power and battery storage forward (2); battery range, cost and replacement life will play a big role in the uptake of electricity (1). Some commentators thought solar powered vehicles are very possible, and their popularity will evolve quickly over time (1). One commentator however, thought electric propulsion will either sink or swim - this will depend on government subsidies, and the price of petrol. However, they would be surprised if electric powered trains are not in widespread usage by 2045 (1).

One respondent felt that electric-powered public transport would not take off, as electric engines do not have the same attributes as internal combustion engines that they are trying to replace. While electric was expected in private vehicles, public transport vehicles would be more likely to be hybrids (1).

Prevalence of automated vehicles

The likely degree of vehicle automation by 2045 was a major point of discussion in nearly all of the interviews. There were very mixed views. Some respondents were adamant that they would be common by 2045:

- “5G [mobile network] is the absolute key to enabling stuff to operate at sufficient speed to provide safety...if you look at where the leading-edge technology is at now, they don’t seem to have any massive problems – in 30 years time there will be even less problems” (Interview 39)
- due to the economic appeal, automation will happen (2), with or without public support (1)
- we are already shifting towards automation (2)
- there will be full automation of general traffic by 2045 (3) and full automation of mobility systems in cities (1)
- there will be a high level of automation which will lead to a broader definition of public transport (2)
- if the technical challenges of autonomous vehicles can be resolved by 2045, there will be serious market penetration of autonomous vehicles (1)
- autonomous vehicles will exist and they will substantially change our transportation system – you will just climb in and go (1)
- if autonomous cars arrive, they will be transformational (1)

- a shift to autonomous public transport would lead to a consolidation, and then a rapid development, into new structures of blended corridor and area-based public transport systems, some of which will work, and some of which will fail (1)
- the cost of transport that is traditionally not considered public (e.g. taxis) will also drop substantially which may change the face of the system we currently know (1).

Others were unsure of whether autonomous vehicles will be prevalent:

- it is difficult to predict whether autonomous vehicles will be in place by 2045 because of public perceptions of safety and security (including public readiness) (4)
- public perceptions are a relatively low barrier to uptake (1)
- traditionally New Zealand keeps cars for a long time, so if autonomous vehicles are present in 2045, it will be in addition to manual cars – there will be a transition (1)
- if automation does occur, it would result in either a heaven or a hell scenario. The hell scenario would be “where everybody owns their own autonomous car, leading to massive increases in the amount of traffic on the roads” (2). The heaven scenario is where service providers own the autonomous cars, and then provide their services to the public (1)
- autonomous vehicles will either promote public transport use or re-enforce private car use and thereby erode public transport markets (1).

The majority of respondents suggested autonomous vehicles will be present, but not prevalent (9):

- automated vehicles will have a place, but that they will not fully replace manual vehicles; people in New Zealand will still want control and independence (1)
- driverless vehicles will help to make point-to-point travel economic and therefore they will have a place in the New Zealand transport system, but they won't fully replace traditional public transport (1)
- driverless modes are unlikely to have taken off by 2045, but there will be some level of autonomy 2045 (7).

Level of automation in public transport

Some thought that if automation does occur, public transport would lead the move to automation as it is already feasible for public transport to run autonomously (7). However, for full automation to exist in public transport, it would require substantial supporting infrastructure (2). Another respondent felt that autonomous vehicles could consume bus services by 2045, but not rail (1).

PT automated

Automation has huge potential for public transport, especially in reducing fare levels by eliminating the need for drivers, and in improving the running costs of vehicles (8); a large proportion of public transport costs are labour costs, eliminating those costs would decrease operating costs substantially (3). Because of this, a large number of respondents feel that by 2045 at least 70% of public transport vehicles will be autonomous (10). Undoubtedly, rail will be completely autonomous (3), but where public transport is manual, the drivers will only be present to give consumers more confidence (2). The ‘driver’ will only be there as a trouble shooter (3). Where rapid transit and core corridor systems exist, these are likely to be automated as well (2). One respondent suggested that

the degree to which New Zealanders are comfortable with autonomously driven public transport will depend on the saturation of autonomous vehicles globally (2).

“I think public transport vehicles could be an early adopter because their routes are more predictable” (Interview 11).

Fare/security concerns

Conversely, some respondents felt that although automation may be good for public transport in theory, there will need to be systems in place to ensure that people pay their fares, to prevent any system errors, and to ensure passenger security (2). One respondent thought that because of traveller comfort, there in fact will not be many autonomous public transport vehicles (2). There will need to be failsafe measures in place (1); full automation, combined with no private ownership, will require ethical considerations, health and safety issues, and risk management (1). There was a belief that failsafe measures could simply be an option for manual override, such as inserting a master key to take control of the vehicle (3).

Manual and Auto

Where public transport remains human-operated, autonomous vehicles will play a complementary last-mile role, unless autonomous taxis become cheaper to use than public transport (1). These personalised options are emerging and could be used as test-beds for autonomous technologies (1). These technologies could go so far as to create a public transport option where you dial up a vehicle that will suit your purpose and destination, and it will then turn up at your door (1).

PT Driver assistance

There was also a belief among some respondents that there will be automation in the form of decision support information (2), or driver assistance (3). Automation in public transport will only exist in modes such as rail where there is a dedicated right of way and exclusive infrastructure in place (1). They believed that it is unlikely there will be full automation in public transport by 2045 (2).

There was however, some uncertainty around the level of automation in public transport (1). One respondent suggested that automation in public transport will be at a low level of penetration by 2045; the automation that will exist will focus more on driver assistance and security, and increasing comfort and ease for the passenger (1).

Guidance

AV guide way

There was a belief that automated vehicles will require some sort of guidance system, whether it is in the form of a dedicated lane, railways, sensors, or data received from a centralised system or other vehicles and infrastructure (6).

It is expected that vehicles will continue to run on the road, but they will be guided in some way (6), which may require technology to be embedded in the road (2) or a centralised control system overseeing the network from a precinct in the city (1).

This guidance is likely to be supplemented by a fail-safe mechanism in case of security or safety problems (2). One respondent pointed to some ambiguities between steered and guided. Many automated features of vehicles use their environment to help guide them, for example road markings for remaining in a lane, but are currently still steered (1).

Automatic system/zones

It is likely that the system will continue to become increasingly automatic, both on guided roads and on railways. Trains will certainly be largely automated by 2045 (3) due to their defined routes and the lack of interaction between drivers and passengers (1). There was also a belief that rapid transit networks will be automatic once risk and safety issues are addressed (5).

One commentator believes that there may be automated zones within the network where the central system completely takes over. On corridors similar to the Tauranga Eastern Link, some sort of infrastructure could be introduced to completely take control of cars (1).

AVs and manual mix

Vehicles themselves could have a mix of both functions, with one respondent envisioning the driver being able to choose whether to 'flick' their vehicle to manual or automatic operation (1); this could be mandated to one option or the other in certain areas (1). One respondent anticipated that in the short-term we will be likely to see a dual-system of manual and automatic vehicles, whilst the long-term plan would be to eliminate manual vehicles (2) as people become more accustomed to not having a driver behind the wheel (1).

There was some opposition to this, with one respondent believing that a computer would control, steer and guide public transport. There would be no reason to keep the driver if safety and security hurdles are overcome (1).

Segregation of modes

Perspectives on the rights-of-way for public transport in 2045 once again differed, though only in cities. In non-urban areas it was anticipated that private vehicles will be more prevalent than in the city. As a result the current infrastructure, and its low cost, would remain (1).

Having segregated infrastructure and dedicated high capacity transit lines was seen as an advantage for public transport, because it would:

- allow vehicles to operate more efficiently and faster (6)
- relieve some of the pressure around peak hours (1)
- provide increased safety benefits (1)
- increase the overall attractiveness of public transport, especially in areas with increased volumes and demand (2).

This segregation could be virtual, operated by a centralised system that will allocate priority and right of way where appropriate (1).

Buses and trams were seen as the most likely modes for segregation, or dedicated laneways (5), due to their throughput and to avoid congestion (3).

Some other thoughts about segregating transport were:

- segregating rail and trams may evolve into dedicated lanes for high-capacity vehicles (1)
- by 2045, autonomous vehicles will be largely integrated (1)
- the focus would be on managing flows as the day of the single occupant vehicle will reduce dramatically (1)
- getting the right of way method correct will be the key to creating a successful public transport system (1)
- segregation will depend on the context of the area, the mode, and the cost: “[segregation is] a solution that has a context, and so it will depend what’s already happening” (Interview 42).
- vehicles will steer around obstacles – kids will be able to play in the streets and vehicles will be able to acknowledge that and move around them (1)
- there could be a road classification system – “on the really local streets the vehicles would have to go around children and obstacles on the streets and the next level of road, they’ll travel pretty much in a straight line and slow down and allow people to cross in front of them and stuff, but there’ll be kinds of lots of people/vehicle interaction” (Interview 49).

Temp segregation

A strong alternative was that while segregation may be necessary during the introduction of new vehicle technology, such as autonomous vehicles, this modal segregation would diminish over time and eventually most vehicles would run on roads (4), or adapted roads (3). In order to achieve the efficiency benefits from autonomous cars, some respondents highlighted a need for manual and autonomous cars to be segregated until the New Zealand fleet is entirely autonomous (3). However, there was also a view that autonomous cars would instead be required to learn how to interact with manual cars (1).

Autonomous for efficiency

Autonomous vehicles will have closer following distances, which is where we will see big efficiency gains, but vehicles will not be able to do this in mixed traffic (2). One respondent also highlighted the safety dangers that a manual vehicle would represent, compared to an automated vehicle (1). Another respondent thought that the segregation could be retained, but repurposed to give priority to autonomous taxis over private, autonomous cars (1). Segregation could transition from technological limitations to priority decisions (1).

High frequency/capacity auto

The only vehicles expected to be fully segregated are those high frequency, high capacity passenger and freight trains that require tracks (4), or dedicated rapid corridor bus routes (8). These vehicles could even be multi-use and flexible; using both roads and tracks to overcome the difficulties of retrofitting cities with new rail (1). An example of this is the Iris Bus in Switzerland – a light rail-type tram that can go on both roads and tracks (1)

It was noted that these mass transit options will still be required in 2045 because, despite the gains we will see with autonomous and connected technology, it will still not be enough to move large

numbers of people, especially in peak periods (1). Priority for these dedicated lanes could be according to some sort of transport hierarchy determined by an economic or public good criteria (1).

The main benefit of segregation is greater speed and reliability on the route. This becomes an issue with autonomous vehicles. If there is a high number of low capacity autonomous vehicles on roads, then it will affect the speed and reliability of buses on the same roads. This may strengthen the case for segregating routes like railways, trams or rapid bus transit (1).

In a dynamic system, lanes will be segregated, or allocated a particular direction, depending on peak travel times; “in the middle of the day you’d have two lanes in each direction and in the evening you would have all four lanes going from the central city to the outskirts. That is essentially the principle with, for example, the Sydney Harbour Bridge” (Interview 49). With more data, automation and foresight, we will be able to make these changes down to 10 minute intervals to respond to demand and congestion.

Rail on roads

Some respondents thought that we will be seeing more and more rail retrofitted onto our roads (2), as steel-on-steel was seen as the most efficient way of moving people and goods; the less friction there is, the more energy efficient the mode is (4). Even if it wasn’t used in the end, rail would be heavily experimented with for use on our roads (1). Ultimately, New Zealand has the ability to choose between a range of guidance and transport technologies that are now available (1).

One respondent, who is an expert in infrastructure development, highlighted an Australian example to demonstrate challenges faced with autonomous vehicles on existing infrastructure: “already they’ve got automated trucks running along parts of the network. They have had to re-programme these trucks to put a wobble in them because they were so precise that every single truck was running within a millimetre or two of [the position travelled on the road by] every other truck. The road was getting absolutely rooted by these *massively* heavy trucks going down *exactly* the same path” (Interview 19). The respondent believed that this illustrated the need to either re-engineer the roads so they can cope with the stress, or to put these kinds of heavy vehicles on tracks.

Conversely, there was a view that rail will start to be replaced by 2045, in favour of high-density roads and corridors. “You might still have rails for high density corridors which are basically a legacy of what’s there now, but I think these will be starting to be replaced by then. Rail is 19th century technology and it’s just incredibly expensive to provide and there’s lots of safety issues with it; it’s clunky, and actually for a lot of services it’s not very high capacity at all because you can only run a train on it – the most dense operations we’ll get at the moment are about once every 45 seconds. I just think it’s going to be replaced and outdated” (Interview 49).

Separated freight

Freight was seen as needing to be segregated to increase its efficiency (3), but only if there was technology to support it (1). One respondent thinks that this has the potential to make it challenging to find places for private vehicles to operate, rather than affecting the where public transport can operate (1).

Private separated

Taking this slightly further, one respondent thought that private vehicles could end up operating on fixed guide ways to better optimize space in highly urbanised areas, whereby cars become guided vehicles that are digitally controlled at the system level. This could apply to urban roads and motorways across an area. Segregation needs to be high if operational performance (flows, speeds and safety) is to be improved, but there is a trade off to be made if cars, public transport, walking and cycling are all to be accommodated. In practice, it may be that cars end up being removed from the urban realm in such situations. Ultimately, private vehicles may well be priced (or regulated) off such corridors or out of such areas if the demand for the road space increases sufficiently – a process which is already underway in some cities (1).

Active modes segregated

Respondents clearly believed that active modes will be segregated from other transport, to increase the safety and attractiveness of these options (5). There will be a push towards active modes as the ‘green’ and ‘healthy’ agenda attracts people towards these options (2).

Conversely, a number of respondents felt that New Zealand just does not have the ability or space in cities to create new infrastructure for segregated transport, including active modes (3). *“I think the real problem is New Zealand’s road space is just so small. All our roads, you know, they’re barely dual carriageway, some of them. I mean, particularly here in Wellington”* (Interview 50).

Infrastructure may not change dramatically where cars already dominate urban space, but they could be segregated from other road users virtually, through automation. Where infrastructure change is likely to happen is in areas with more people than vehicles (Interview 49). An example of this may be the redesign of traditional streets into pedestrian only zones, or a shared space.

Supporting infrastructure

NZ is already invested

A majority of respondents had the view that because New Zealand is still building roads, rail and other infrastructure now, that will still be in place in 30 years time (13). However this infrastructure may have different technology on it (4), such as autonomous trains (1) or vehicles (1). Slight adaptations to current infrastructure will still be cheaper than any other option (2). The focus could also move towards bigger and higher capacity public transport lines (1). It was also suggested that physical segregation of vehicles could no longer be necessary with the safety gains from automation (2).

Manual cars

It was suggested that some drivers will still want to operate their historic, manual cars, and they will need to have space to do this (1). There will also be areas where automation is not appropriate, such as on unsealed roads. Manual cars will need to operate in these situations (1). One respondent disagreed however, stating that the infrastructure we are currently building is not conducive to driverless vehicles, and so automation will not take off in New Zealand (1).

Other infrastructure

Different infrastructure and guidance systems were proposed as holding some merit:

- optical, magnetic levitation or GPS-attuned guidance systems were mentioned for their safety and efficiency benefits (1)
- embedded or virtual guidance technology was seen as having the ability to remove some of the need to have segregated forms of transport, as it would allow a mixed use of the new and existing infrastructure (2)
- tracks were suggested as being an important method of creating an efficient and comfortable transport mode; the reduced lateral movement creates a more enjoyable trip by diminishing the prospect of motion sickness (1) – there is a challenge inherent in tracks however, as they are very costly to create and install (1).

One respondent suggested that the supporting infrastructure will be mainly IT-based. It will not just be physical infrastructure, but the technological infrastructure that allows data collection, analysis and use, for example.

A transport and geography expert's view was that "it will be largely automatically steered and the guiding system is probably going to be IT-based in some way, not physical kerbs or rails, but it might need some marked reference points on the roads depending on what's gone for. Not GPS of course; that is too risky. It is all very well for navigation but not for steering purposes. It's not accurate enough and it's too risky in terms of somebody hacking into the system" (Interview 11).

Another respondent noted that context will play a big part in deciding what infrastructure was used where, and this may vary city to city. "Potentially all of those things actually [tracks, road or something else] and I think, what we see around the world, even now, is just different solutions for different contexts, and I think that'll be the same in New Zealand. You'll have a solution for Auckland...which won't necessarily be the same solution for Wellington because of the context" (Interview 42).

Air space

One respondent thought that as well as the horizontal overlay on the landscape we are accustomed to, there would also be an increasing vertical overlay, an airspace component. This space is becoming even more important with a lack of ground space, which is likely to be prioritised for commuter parking and peoples valued urban lifestyles. The solution will be to raise it up over the landscape, with either a modern form of powered rail or with conventional traffic. This presents an opportunity to maximise air space building rights (1).

EVs

One commentator alluded to the infrastructure requirements for electric vehicles. They believe that electric vehicles will utilise park and ride spaces and parking buildings to re-charge, rather than on-street charging. Current petrol stations would also develop the necessary charging infrastructure (1). The idea of induction charging, or something else embedded in the roads to charge the vehicles, was also raised (4).

Optimising/sensors etc.

It was a clear theme throughout the responses that public transport infrastructure will optimise routes with new technology, which would include sensors that can detect dangers on the road (1). For example, sensors are already embedded in some New Zealand infrastructure that have the ability to detect ice on the roads and warn motorists (1). Some respondents felt that while there could be a mix of segregation levels, we would see a lot more vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-aggregation systems communications, which will significantly reduce the need for pure segregation (1). The data gathered from intelligent transport systems are just as much supporting infrastructure as anything physical – they are picking up data that will ensure the system works better and the traveller is informed (1).

Consumers needs and demands

The needs and demands of consumers will be the force behind any change in supporting infrastructure. With the availability of smaller vehicles for single point-to-point trips, people will be dropped off closer, or even at, their own homes which will remove the need for low-demand bus stops (1). There does however, lie a balance in these trips between having the flexibility to make them, and from not being slow in picking other passengers up – this balance highlights the value of bus stop and train stations (1). These smaller point-to-point automated trips also raise the question of whether parking buildings will be necessary in urban areas. Perhaps larger pick-up/drop-off areas will be required instead (1). If we do see parking buildings they will be more like temporary housing for automated cars during low-demand times (1) and, as mentioned above, as a charging station for electric vehicles (1).

There will be a high focus on amenity and a consideration of how the technology and infrastructure functions socially. We will see an increasing focus on the integration of urban design, urbanisation and transport (1).

Control of the System

Centralised system

Some key points on a centralised system are as follows:

- some sort of central system would most likely be used for efficiency purposes, if not for guidance (7)
- automatic vehicles will run as part of a system and not on their own (1)
- manufacturer standards will play a part in determining whether or not the vehicles are controlled by a centralised system, or operate independently. We are currently struggling to get the universal standards we need to create a centralised rules-based system, so we are more likely to end up with a spectrum of control systems, just because it is too difficult to have everything working to the same standard (1)
- there will be one 'big brain' controlling the system, with a number of 'subordinate big brains' that report back to the main control centre; this system would mitigate the chances of hackers, or other security threats (1)

- “my presumption is that there would be either a central thing that is the modern electronic equivalent of the current traffic control centre, or maybe a whole lot of them linked up” (Interview 3).
- by nature, rail could easily be controlled by a centralised system because of its strongly defined network. However, buses would need to have the ability to run independently. Outside of normal bus routes they need flexibility to change their routes to meet demand (1).
- it is likely that vehicles making public trips, either small vehicles or mass transit, would suit a centralised system, but those making private trips would not –particularly while there are still manual vehicles on the road (1).

The extent to which local communities can upgrade their infrastructure to make vehicle-to-infrastructure possible is slight, which will affect what method is put in place. “They might upgrade the infrastructure to a point where they can just tell where cars are, or lesser still, they might replace traffic lights with round-a-bouts or priority junctions where possible and leave the cars to interact with each other” (Interview 7)

Fear of cyber-security issues creates a substantial barrier to the introduction of centralised control systems (2). Unless this fear can be mitigated then these systems will remain dangerous in the eyes of the public. Completely autonomous vehicles will be more in demand, despite the potential issues in updating infrastructure to comply with the needs of these vehicles (1).

Independent System

Some respondents saw a centralised system as not being necessary. Vehicles would not need to be steered or guided, as they will be capable of controlling themselves (7).

- Vehicles will be independent and control themselves (1).
- Vehicles may be able to connect to other vehicles to send an ‘*I am here*’ type message for the purposes of negotiating interactions (1).

Centralised + independent systems

Others saw a mix of centralised and independent control regarding how vehicles might work together (10). If a centralised network were in place, it would act like a big brain in control of the transport network itself, designed to optimise efficiency (12). This would be by dispatching vehicles, allocating priority to high-capacity vehicles, and undertaking other management functions (5). However, vehicles would need to be independent within this system to successfully interact with each other (4). This interaction would contribute to the vehicle mapping the world around it, in order to successfully control itself (1).

- “Vehicles will be independent, they will control themselves, look out for children and all that, *but* they will still have to book in with a central system to register where their route is and where they’re going. That will allow them to talk to other vehicles which will allow you to get the capacity benefits” (Interview 49).
- Vehicles may send signals to the central network, even when they are not operating on the network, purely to optimise the system (1).
- The central control system will determine priority (3).

- Vehicles doing private trips will cede to vehicles doing public trips, as the individual vehicles doing public trips can join together for efficiency, whereas vehicles doing private trips will not – a central system will determine who cedes to who (2).
- A central system could be an opt-in service for an extra cost – it will prioritise the journey and calculate the most efficient route. However, choosing not to pay for it will mean queuing up in the system with everyone else (1).

Platooning trucks were given as an example of a combination of control in use (2). They involve a central system where vehicles can automatically join a platoon down the motorway. However, when they leave, the truck then becomes independent again, so a combination of systems would need to work well together (1).

- There may be areas on the network, where all vehicles connect together and are guided by a peer-to-peer integrated network, such as platooning, to increase efficiency (1). Some commentators believed that platooning vehicles would be commonplace between all autonomous vehicles, whether they are public or private, to increase efficiency (2).
- While there has been speculation that platooning could evolve into vehicles connecting to create a single unit and then branching off when necessary, one respondent highlighted this as highly unlikely due to the difficulty of co-ordinating where vehicles would disconnect and ensuring people are in the correct area of the unit (1).

An international public transport expert provided reasons for the combination of both an independent and central system. “I think they are just emerging at the moment, it’s going to be, I wouldn’t say a struggle between those two, but that is a thing that is yet to be resolved, because we don’t know how safe from cyber attacks, the IT systems are going to be. But equally, autonomous vehicles can be designed to be entirely independent and operate independently, but that does have implications for infrastructure, because you therefore retain entirely, your signalling and your control infrastructure, as if it were manual, but it will need to be available for the autonomous vehicles to read, understand and communicate with. However, probably you would need to have that dual system anyway, for the short-term future, and possibly for the long-term future you’re planning to totally eliminate manually driven vehicles (Interview 8).

Public transport payment systems

Opinions on the future of ticketing and payment systems were fairly consistent across the interviews, with the main points being that journeys will be paid for in a less intrusive manner, while pricing will be more sophisticated and dependant.

Seamless, integrated ticketing

The idea of seamless and automatic payment systems between journeys, modes and operators was communicated strongly among the respondents (18). Payments will be digital, whether that is credit card or account based (15), and completely contactless (7). Tickets will be long forgotten, especially individual tickets for each journey (4). Whatever the payment option is, it will be fast and allow people to board as quickly as possible (2).

Transport packages

The idea of getting rid of transport smart-cards (2) and moving towards 'transport packages' came through in a number of interviews, which would give people the freedom to optimise their travel needs through an individual package (3). These packages would work with Mobility-as-a-Service (MaaS) systems, and look similar to a telecommunications service: "so you might get your commuter needs, your weekend needs, and your party needs all bundled up with so many kilometres of different services" (Interview 46).

Payments could be made via cell phones or other digital devices (1). This payment would be made prior to getting on the bus, or whatever transport it is, so that people do not slow the process down by paying as they get on (1). There was a concern however that, despite the technology being obsolete, the investment that has been sunk into the smart-card system means it will be around for a while (1). Another respondent suggested that this could result in a combination of payment systems, although cash would not be used (1).

One commentator expanded this concept to say that payments for everything will be integrated, not just transport, but electricity, shopping and recreation, etc. (1). A similar view was "that transport will become increasingly a bundled service, so you for example might select a restaurant you want to visit and part of the process of going to that restaurant would be getting an autonomous shuttle there and back, which would be like a courtesy vehicle" (Interview 11).

Uber method

In addition to the MaaS method of payment, two other methods were raised as possibilities. The 'Uber method' of paying, where the user can just walk away from the vehicle without thinking of payment (3), has proven to be effective from a customer satisfaction point of view as there is very little required of the passenger (1).

The idea of a 'virtual-butler' was also raised (1): "if I've indicated that I am going to need to be in a different location for a meeting for example, the service is going to know that I need to do that, in advance, through wherever I have recorded it" (Interview 26). This method would work in a similar style to the 'Uber method'. When a journey is chosen the virtual butler initialises payment (3).

There would need to be a number of pre-booked seats that could be booked in advance, as well as some 'spontaneous seats' to cater for unanticipated travellers (1). Most likely to be completed through your smartphone, another respondent added that the service would already have information about your preferences and be able to recommend the best journey (1).

Alternative ideas

There were some diverging views on what the form of payment will be. Applications on smartphones were thought to be a strong possibility (6), although some questioned whether mobile phones will be overtaken by some new technology by 2045 (5).

Others thought that implanted chips or sensors could automatically charge us (5) and that people would simply be tracked and charged for their usage (2). Alternatively, payment could be made through some form of biometric device, or retinal scanning, or something similar, that will identify a person, connect to their personal /business account, and debit them automatically (3).

No matter what the payment system is, there needs to be a way to split the payment to cater for situations where we are travelling in one vehicle with strangers who are going to the same destination as you (1). It was thought that the system would need to be appropriate for all parts of the public transport network (2), it would need to be transparent (1), and easy (6). One respondent believed that the type of payment method would be demand-driven, as it will not make a substantial difference to the system what method is used (1).

There was a converging view however, that due to local monopolies on public transport, integrated ticketing is unlikely to be commonplace (1).

One respondent feels that payment methods “will very much depend where you are in New Zealand. ...in some of our smaller cities, or smaller urban centres, [integrated methods] might not be worth it. However, I would think in our bigger cities - and when I say big cities I mean Auckland, Wellington, Christchurch, Hamilton, Dunedin, Palmerston North, Tauranga is really growing, and Queenstown’s got some growth. In these areas, you’ll have cashless, integrated payments. That kind of technology is developing really quickly” (Interview 42).

Public transport pricing

Supply based pricing

Respondents suggested there will be significant changes in the way journeys are priced by 2045. Users could be charged depending on the time of day they travel (8), the distance they are travelling (5), the level of comfort or space they have (10), the mode they are using (1), or the effort the operator needs to expend to deliver the service (1).

It was anticipated that pricing would become much smarter (1) and involve mechanisms such as surge pricing to ensure supply meets demand, especially during big, local events (4). The pricing could also involve some kind of behaviour element that would reward good transport modes and potentially penalise the use of higher-impact modes. Such behaviour elements would be determined by social values and environmental goals (3). Private vehicles may even need to book slots to use road space, and that data will be collected to help fix appropriate prices to optimise use (1).

One commentator suggested that public transport fares could be cheaper during peak times to encourage more people to use buses, to better optimise the entire network (1). To fully recover the cost of transport, it was recommended that the rational choice would be to price across all modes, not just individual ones (1).

Mobility miles

‘Mobility miles’ were also suggested, where travellers purchase annual mobility caps and can travel as much as they like until they reach that cap (1). ‘Mobility miles’ could even be tradable to allow you to transfer miles, or sell them at a premium, to those who need them (1). Some modes might have ‘cost miles’ which could be carbon-based ‘miles’ to reflect the impact that they have on New Zealand’s carbon emissions (1). Along those lines, another respondent suspects that there will be considerable regulation around social and environmental goals (1).

Multi-modal = single price

One respondent thought that the pricing model will move towards a best-practice method of pricing that can still be explained to people. Multi-modal journeys will be priced as if they are a single mode, as long as there is a single operator across all modes. There are currently too many stakeholders involved to integrate the pricing methods (1). However, another respondent disagreed about the complexity of the method. They noted that electronic ticketing means that the payment structure is not visible to the user, and can therefore be complex without being complicated for the user (1). One commentator saw the importance of cognitive thinking in pricing – i.e. users don't always want to be doing sums and utility value calculations in their heads, and so this is where technology, with better information and better capabilities, will do the thinking and allow for more fine-grained pricing (1).

Climate change

The cost of addressing climate change could mean the cost of mobility rises significantly, even if there are low carbon forms of transport, so the rich would continue to travel while the poor would experience much less mobility (1). A key decision of the Government will be whether transport use is priced with users paying the full social and environmental cost of each journey, or whether subsidies will remain in some way or another (1).

Active modes priced

One respondent felt that people will be happier to pay for services that at the moment are free, like cycling or priority routes. Road pricing will be acceptable, especially when people are concerned with getting to work faster, but it would need to be seamless to be acceptable. There could be some kind of package that included access to a range of modes or services at a flat rate, paying up-front for the services (1).

Subsidies for public transport

There were few comments on the use of subsidies in public transport. Participants suggested that:

- the need for subsidies will decline over time as rapid transit systems become more successful and fare box recovery increases – this would require separated infrastructure for the rapid transit systems to avoid congestion and increase efficiency (1)
- on the flip side, there will still be a need for subsidies as very few public transport systems are able to fully recover costs from the user, and those subsidy frameworks would remain similar to those in place today (2)
- the operating costs of public transport modes will continue to be challenged as automation levels increase (3)
- by 2045 there will be a lot more free transport provided, especially as automation increases and the cost of running transport decreases (1).

Hub-and-spoke versus point-to-point

Combination hub + point

The vast majority of interviewees expect service patterns will still involve interchanges, whereby high frequency services are hub-and-spoke, and smaller, direct trips are point-to-point (21).

- Low-frequency bus routes that currently provide area coverage will no longer operate, and will be replaced by MaaS options (1), which will be more individualised (1).
- Automation, guided vehicles and overall better management of point-to-point travel will accentuate this (1).
- Automated vehicles will be used for the ‘last mile’ problem (1).
- The hub-and-spoke system will remain particularly important in cities (5) that are experiencing large population growth (1) and where the majority of people are going from an origin to destination (1).
- Patronage demand will justify point-to-point travel rather than rapid transit spines in smaller towns (1).
- The hub-and-spoke model could physically turn into a point-to-point model by detaching from a larger vehicle, or joining another (1) – people don’t like changing vehicles (1).
- Hub-and-spoke works well depending on the economic geography that is present (1).

Point to Point

It was suggested that the system could become increasingly point-to-point, where an individual vehicle can join onto a high-capacity corridor and then leave it when necessary, rather than the passenger having to change modes (2). “I suspect what might happen, is an approach where you have a ‘dial a pod’ type vehicle that would pick you up and it would take you to a particular corridor. Then, on this higher density, high capacity corridor, there might be a moving conveyor belt type thing, or similar. The pod will basically just sort of slot onto this system while it’s still moving, and the system would just carry all these pods until they want to leave; then your pod would automatically disengage and then travel off by itself. So, even though the system might be hub and spoke, the person’s experience of that wouldn’t be – it would still be quite point to point. And, that potentially might give you the network benefits while keeping the passengers from having to change, to make it more attractive” (Interview 49).

A point-to-point system will be “consistent with people’s greater demand for mobility and levels of service. I think the days of a hub and spoke network, whilst I don’t think it’ll totally disappear in the timeframe we’re talking about, it will certainly be of lesser significance” (Interview 35).

Suburban areas

Hub-and-spoke services can work well in urbanised areas around centres, whereas point-to-point services are preferable in less densely populated areas and on highly used corridors (2). While urbanisation is currently continuing, it is possible that this could tail off to some degree. The passenger experience is deteriorating, not only because of congestion, but also because of the need to increase capacity. Thus, passengers are being (and will increasingly be) forced to interchange more across a network because of increasingly congested city centres. Therefore, if you live on the south coast of England, for example, you might now be able to get a train straight through to London, whereas in the future you might have to take a feeder service to a station and then change onto a trunk service into the capital. Hence, connectivity will be important (1).

Interchanges

The transport interchange will develop into a destination, with mixed-use retail, commercial and residential spaces, which will be another source of revenue for the transport network (4).

There were a number of comments made in respect to the transport interchange.

- Interchanges will incentivise travellers to use the corridors in the first instance and the point-to-point networks for the last mile. (1)
- They will allow the hub-and-spoke network to interact with multi-modal point-to-point options. (2)
- It is the best choice from an economic perspective, but it will need some national co-ordination to ensure an effective and smooth interaction between modes. (2)
- While the focus will be on a seamless journey with minimal transfers, a hub-and-spoke model, with interchanges, is likely to be unavoidable. (1)
- Interchanges will allow for more diversity in short-distance trips, such as autonomous vehicles playing a feeder role to public transport interchanges. (1)
- Hoverboards, electric skateboards or other small personal travel devices will be used as feeders to an interchange. (1)
- Park and ride will be used as spaces for charging electric vehicles, including the feeder-cars delivering people to the interchange. (1)
- Land required for the park and ride spaces will reduce as car-sharing becomes more popular (1), but they will still remain an important part of transferring people from local neighbourhoods to hubs and interchanges. (1)
- There will be a decline in conventional bus feeder services, and an increase in car-sharing autonomous vehicles with more services available at interchanges. (1).

Dependant on environment

Point-to-point or hub-and-spoke is a function of the environment – both can work depending on the context (2). Autonomous vehicles are more likely to be used in a hub-and-spoke model where you take the autonomous vehicle to the hub (1). Rural areas are more likely to be a hub-and-spoke model where those autonomous vehicles can deliver people to the appropriate interchange (1). another respondent suggested there could be some hub-and-spoke services, but that the system will mostly be point-to-point as there will be a lot of spare capacity in automated vehicles, which means you don't need to rely on a main corridor (1).

Dependant on vehicle size

Point-to-point travel will be served by more appropriately sized vehicle. Currently there are a lot of empty buses on low-demand routes, in off-peak periods, which are there for social need rather than due to service demand – this is not an optimal use of resources (1). One commentator believes that this style of point-to-point service is likely to completely take over the hub-and-spoke model as vehicles are developed to suit different needs and quantities. They will get people where they want to go with minimal transfer (1). This will be supplemented by increased information through technology that will help people to synchronise their travel on the networks (1).

Accessing travel information

In terms of accessing travel information, some respondents said that timetables would no longer exist, while others mentioned that they would evolve in various ways.

No timetables?

Passengers will not use timetables, either because the corridor-based high frequency services will be frequent enough so that people will just show up and a service will arrive (20), or because the low frequency services will be replaced by on-demand alternatives that people will book when required (4).

Headways will be more important with high frequency services to ensure the services are consistent (2). That said, there might be real-time information provided, perhaps at transport access points or via some sort of personal user information device (4). Some respondents agreed with this, thinking of them as a type of timetable, but not in the way they exist now (2). Timetables will be more relevant for corridor systems and irrelevant for network systems (4).

However some respondents thought that timetables will still exist, as the efficiency of putting everyone on a narrow route when they are all going to the same place, at the same time, is hard to get past (2). People will still want to know when the next bus is arriving, unless they are living in a highly dense area where buses arrive less than every two minutes (3). If this information is presented through a smartphone, or similar, it is likely to be supplemented by reassurance information at the stop or station (1).

Info through personal devices

The general consensus was that information would be accessed through some kind of personal device, whether that was a smartphone or the next evolution that exists in 2045; but there would need to be a full range of information available, rather than simply a list of times (16). The information will be app based and not like the conventional timetables or information we know today (4); users will say they want to go from A to B and the app will tell them the best way of doing that, across all modes and service types (6). The applications will allow tracking of buses, trains and ferries (2).

This information could also be available through other personal electronic devices that are more 'slick' and accurate, for example Google Glass, or some other wearable device (2). They will be able to match your pre-set preferences with information about the best journey for your needs (1). The application, or device, may also have the ability to tell you when to leave your desk to catch a certain bus or service – real-time information and known preferences will mean you do not have to waste time waiting for the next bus (4) – just like a virtual butler.

An interesting point was raised here, about who should own the information and applications:

“There's a separate question then about do you want this big central place [where information is accessed] to be free? Currently Google or Tomtom owns a lot of it and it is treated as a public good type-thing and something we'd like to have. But essentially, it's a big set of data which is then provided free to hundreds of app providers who do their own analysis and then provide the information that we want. Is that the right way of operating?” (Interview 3).

Another respondent suggested that the assumption that the smartphone will remain important to us may not be entirely correct. Having hundreds of applications on your smartphone is cumbersome. We may see personal organisers instead that get information directly from the environment as it increasingly becomes connected to the Internet of Things (1).

Scheduled and fixed routes, versus on-demand operations

The general expectation here was that bus and rail services would continue to operate to fixed routes and schedules, particularly on high demand corridors. However, that may well mean an increased use of demand responsive and flexibly routed services in less populated areas.

High Frequency

There will be less reliance on timetables as people just expect vehicles to be there. If they miss one, the next one will only be 5 minutes away (5). The more flexible and personalised transport options (point-to-point, Uber style) will not need a schedule, but the fixed route, or corridor services, will – whether it is bus, train or ferry (22). They will be more customer-focussed in terms of what customers want, where they want to travel, etc., which will be helped by improved information and knowledge about people’s travel behaviour (2). There will be more shuttles or shared rides, etc. for smaller groups not travelling on the fixed route, high-density services. Greater density in cities will mean more frequent mass transit services (1).

Schedule of some description

Some respondents felt that, given the number of people that need to be moved, getting away from a schedule of some description will be very difficult (7). Public transport needs to be reliable and this may mean scheduled and fixed routes (5), even if it is automated (1).

There were several suggestions of how this could look:

- it could be a blurring between what is now referred to as a schedule, and real time information (1)
- another suggestion was that this could mean a fixed route for urban systems, and a flexible, on-demand, catchall system in rural or suburban areas (3), but the difference would be that automated vehicles would wait for people and not the other way around (1)
- alternatively, only rural areas would not be scheduled; because of the low density scheduling will be required to maintain efficiency (3).

A public transport expert mentioned an ITS study that was recently undertaken in England. [“An interesting study that ITS Leeds did a couple of years ago in Shropshire, operated an hourly bus service between two towns, via intermediate villages. People were given a willingness to pay response just on options of either demand responsive or a two-hourly fixed route. A two-hourly fixed route was given a higher valuation than demand responsive, which might seem quite surprising. But, it’s a function knowing the bus is there at certain times, you don’t need to pre-book, there’s a more certain duration of journey time once you’re in the vehicle, so people can trade off just surprisingly low frequencies in some cases”](#) (Interview 12).

Completely flexible

The idea that there will be no fixed schedules or fixed routes in 2045, that it will instead be a completely on demand and flexible transport system, was also suggested (3).

An alternative was the idea of ‘nearly fixed routes’, where the bus driver could detour off the route if there were people using the service that did not want or need to complete the whole route (1) – the route would be determined to some extent by passenger demand, but general areas would be

determined by the operator (1). The improved real-time information will also mean the operator has more flexibility in their routing (1).

On-board experience

Overall, there was a split consensus as to whether the on-board experience would improve, whether that was with introduced Wi-Fi or premium spaces at a premium cost, or whether it would stay very similar to the current experience.

Similar to today

Some commentators believed that most of the public transport facilities existing in 30 years are probably already here today, so the onboard experience will be similar (8). The general look of buses and trains hasn't changed much over the last 100 years, although there might be small incremental improvements in comfort and amenities on board (6). There may be more spaces for screens, or connecting and charging personal devices, and providing the opportunity for passengers to do other things while travelling, but ultimately people will want the familiar – they will still want to look out the window while they travel (2). It will not be physically possible to get the sort of comfort that you expect in a private vehicle (1).

However, there were some exceptions to this. There were debates as to whether comfort of capacity would win out, and whether the market would demand it, or operators would provide it.

Utility

Onboard experiences will be less about looking at roads and driving, and more about doing stuff that is more useful with your time, because increasingly people are being squeezed for time (6). The passenger will have the opportunity to shape their own onboard experience through the mobile technologies they have with them, and use during their journey (1).

“If the car is doing the driving, then the driver does not need to have a steering wheel or pay attention to any of that, everybody becomes a passenger” (1). That being said, maybe we have reached a saturation point in society, where accessing yet more information is actually a bad thing, and that instead people may value leading calmer lives, working less hours, and maybe having fewer bits of useful technology, but being much more discriminative about what technology they are using for what purpose (1).

Market driven

The onboard experience will depend on the markets and transport policy aims. Some services *“will just want to cram people on” (1)*, whilst others will want to attract the discretionary traveller with a better experience (3). There will be an inevitable tension between speed, capacity and comfort (4).

If the demand is there then services will differentiate their on-board experiences. They might even provide food or individualised space and a premium carriage, perhaps at a higher cost (12). *“There is already a start-up in San Francisco that offers basically a cafe style public transport ride to work, it costs more than the usual public transport but you get more amenities: they cap the number of people who can get on, you can get coffee, all different kinds of things” (1).* Another example was given of Hong Kong; there are *“air-conditioned buses, express buses and not air-conditioned buses and not express buses, and there are different fee schedules in those buses” (Interview 48).*

Where there was extra personal space, it would not need to be a large amount of space, one respondent suggested that: “the footprint that the passenger needs to feel as though they have unpacked the technology they use into that space, and create their own mini environment...is getting smaller” (Interview 10).

The demand for these kinds of services will spark innovation within the sector and industry, which will in turn attract more people to public transport (1).

Dominant paradigm: there will be more focus on comfort and amenity, particularly connectivity services

Comfort and Connectivity services

Connectivity services were expected to become commonplace on public transport. Some commentators think that rapid transit networks will have high-quality onboard experiences, such as Wi-Fi, USB ports and workspaces for the ability for people to work, or make use of their time, while travelling, at no cost to the user – the focus will be on more comfort and amenity (18). There will be a broader range of opportunities for how people want to use their travel time (3).

As mobile data becomes cheaper, free Wi-Fi will become less of an issue, however one respondent stated, “free Wi-Fi is wonderful, but free Wi-Fi usually means crap service, so I’ll pay for the privilege” (Interview 2). Some thought this could be a dramatic change including TVs, computers and other entertainment (2); others were of the belief that it will be about allowing passengers to utilise their own technology in their own way, rather than including screens and other technology in vehicles (1). It was also suggested that there “could be a niche market for appendages users can take onto public transport; for example, a briefcase that includes a small ‘perch’ or seat for use when there are no seats remaining on the particular vehicle” (Interview 10).

On individual comfort and amenity – “a greater degree of the comforts and the add-ons that the car can provide [to attract more people to public transport]. So you can listen to the music that you want to listen to and not the guy with his ghetto blaster further down the bus. You will be able to have the temperature setting that you want, rather than a general stuff, so I think individual comfort will be a bigger aspect of the service” (Interview 35).

One commentator thought passenger experience could go either way. They suggested time is the new distance, so making better use of time such as using the internet while travelling might be the way forward. Conversely, transport could be configured to “be cocoon like with no connectivity so that people can just switch off. Either way, it will be much more refined than it is today” (Interview 6).

There will be lots of different demand and needs from different users and some of those demands will be commercially visible and catered for, while others will not be (1).

Who will be using public transport?

Dominant paradigm: a more diverse group will be using public transport

More diverse group

Looking at demand characteristics and future public transport markets, there are several ways that these are expected to change. Taking a general view, one thought was that public transport is becoming increasingly acceptable among certain groups – in particular, the young and the old, and the city dwellers more generally (6). The current stereotypes of public transport being for the disenfranchised will be broken down (6) and there will be a much broader market and mix of people using public transport (12). This will be even more so as the definitions of public and passenger transport begin to blur (2) and on-demand, flexible transport becomes more available (2).

There may also be a select group of people who own vehicles, but then allow them to be used by other people when they're not using them – like a community or group car sharing club. This operating model is likely to encroach on the traditional idea of public transport to create a blend; individuals almost become operators themselves (Interview 49).

However, there remains a *squeezed middle-aged group who remain snobby about public transport and where car ownership will retain its status* (Interview 4) (4); though their attitudes may change on securing their concessionary fare passes (1). Another respondent thought this would change on its own, although very slowly (1).

Aging population

It is also going to become increasingly convenient to use public transport, more so than private transport, so a majority of the population will be using it (2). One respondent recommended that public transport systems should be designed to support all ages and trip types (2). As the population ages, those who aren't comfortable behind the wheel or who are disabled will increase and be more likely to use public transport (7). Transport is just one part of accessibility however, jobs, housing, environment and urban limits all have a role to play in how transport operates effectively (1).

“There will be three big groups [using public transport]. The biggest group will be individuals with personalised transport, holding the belief that they are the most important person in the whole system and everyone else should be subservient to all of their needs. The other two groups, the disenfranchised group and the elderly transpired, will be interfaced in a very different way. The needs of the elderly who once used to drive and be independent, but now have to rely on public transport, will present problems. There will be niche services to accommodate the lower income and disenfranchised groups, but the service quality is likely to be low for those people” (Interview 16).

Dependent on work

The pattern of work activity will be important in creating concentrated peak demands at various points on the network (4). If there is a change in the current 9-5 workday, then travel demand will change and service providers will need to be prepared for that (3). What won't change, is that people will want to get from A to B without hassle (1).

There will always be a proportion of people not using public transport (such as plumbers, couriers, etc.) but more people than today will use it as it is an easier way to get around (2). The wider range of people anticipated to use public transport will do so as the services improve, personal vehicles are

'squeezed out' and convenient door-to-door trips are possible (1). We can already see in urban areas that who uses public transport will depend on how attractive it is (1).

Related to this is the level of retirement, linked closely to the aging population (1). "If the people that are creating peak travel demands are retired in 10 or 20 years time, then there are obvious implications for public transport and travel demand" (Interview 12).

"Education travel (i.e. school students travelling to and from school) generates peak demand and often justifies quite large vehicles – so one issue immediately arising is whether education will still have the same traditional classroom, fixed-site, format" (Interview 12). This person saw this as a determinant factor for who would be using public transport.

Everyone

Some respondents think that by 2045 everyone will be using public transport. They will have realised that it is more efficient than using a private car in traffic; particularly due to increasing population, high-density cities and the reduced focus on inner-city parking (2). For example, people in London who can afford to drive don't, because the quickest way to get into the city is by public transport or cycling (1). If shared services become more popular as a public transport choice, it was thought to again, be more attractive to everyone (2). There may however, still be a small 2% who can afford to use their own transport (2). One respondent thought that there will be a reduced travel for some people as they get better at doing things in their own homes, but there will also be an increase in those who now have greater options for access to transport, such as through shared transport (1).

Depends on pricing and wealth

Pricing and wealth was thought to play a significant part in determining who uses public transport (4). If all transport becomes expensive, such as through the response to climate change, it was suggested that only the well-off will be able to afford public transport. So, the well-off could afford to work in distant locations, while the poor are restricted to jobs in their immediate area (1). It will come down to who is providing the public transport – if it is publicly provided then there is likely to be a catchall for poorer people to access transport (1).

One respondent claimed that there is a 30/30/40 framework for who will be using transport. 30% of the population will have a secure life – secure income, occupation, etc. 30% are on the margin – zero hour contracts, no job security, no pension provision, etc. Then, 40% will be the increasingly elderly or low-income groups. This last group will dominate public transport use (1). We have seen older and younger women using public transport more, but this will break down and the gender balance and use will be more neutral (1).

AVs

If autonomous vehicles take off, then there may be less people using conventional public transport, especially for the elderly who do more point-to-point travel, or schoolchildren whose parents will no longer need to drive them to school (1). People who currently use public transport because they have to, rather than because they want to, may be steered towards the attractiveness of autonomous vehicles instead (1).

Public Transport Ownership

Another respondent suggested that who uses using public transport will depend on who owns it. If it is a private company such as Uber, then fewer people will be able to use it. If it is state-owned, everyone could use it; if there is a mixture of both, government will have to provide a subsidy to ensure everyone has access to travel (1).

The difference among the groups using public transport is speculated to grow; a respondent noted that it will be on the government to manage these differences (1). We will have a greater understanding about who is using public transport as technology and data collection continues to grow (1).

Urban versus rural areas

Dominant paradigm: conventional public transport in rural areas will decline, while urban areas experience a dramatic growth

PT in rural will decline

The difference between public and passenger transport in metropolitan areas versus suburban or rural areas, is based on the level of demand, patronage, the associated infrastructure that is available and the cost of providing services in those areas (2). Because of this combination, conventional public transport in rural areas will decline (9) or cease to exist because the declining rural population cannot afford it (2).

More people will move to urban areas, and small vans or personalised services run by private firms may only exist in rural areas to support the elderly, or those who do not have access to their own transport (4). Autonomous vehicles will provide the alternative to suburban or rural public transport (3), or will help connect people to a hub or metro area (1).

Public transport in urban areas will continue to evolve and develop, and the suburban areas will see a better service as a result; but one respondent thought it was hard to see any changes in rural areas as their travel choices do not really affect their economies (1).

High demand/Urban more used

In terms of the urban versus rural markets, public transport will be used far more for trips on high demand corridors, as driving becomes more difficult and expensive due to more effective pricing mechanisms being adopted. Anybody who is going to high-density areas, such as a city centre, will use public transport to get there – especially where driving (or using a public vehicle) will be too expensive or difficult to use (1). This cost could be a societal cost, or an actual cost (1). One respondent felt that only people in cities will use public transport because that is where it will be. They didn't think it was practical to offer public transport in rural areas, and that as a result public transport will only serve those who need to move along the mass transit corridor (1).

Demand will spread + grow in suburban areas

There were a number of comments made on the provision of transport in suburban areas in 2045:

- while the population is set to grow in urban areas, travel patterns are changing such that demand will become more spread, and that will be a socio-economic influence on people's behaviour (1)
- trips downtown in many areas are generally becoming a proportionately less important destination for many trip types (particularly commuting); people may still travel to work everyday, but less than half of people currently follow the 9-5 schedule and the trend anticipates the proportion will continue to fall. Therefore, although the demand for high frequency, high capacity services into high-density areas is going to exist, it will be a smaller share than today (1)
- the efforts of operators to optimise their capacity will help force that spread, which will hopefully have some positive effects on public transport (1)
- there is diversity in urban public transport travellers, but in less urban areas (moving towards suburban or rural areas), the market is generally a captive market of users who have no alternative (1)
- the suburban demand, in particular, will grow and the public transport network will have to reach further afield (1)
- if there is more diversity in services, then there will be more diversity in users (1)
- as you move away from the more dense areas, there is likely to be smaller units serving as public transport modes (1)
- another respondent agreed with the need for diversity, but felt that the mix of transport options was already developing with the core of cities moving towards public spaces (for active modes like walking or cycling), as well as developing infrastructure for both public and private travel (1).

An alternative view, was that there remains to be a transition to a fully networked means of production in New Zealand, which would result in a spread of metro areas, into what we currently consider to be suburban (1).

Aging population - rural

New Zealand is set to experience an aging population over the coming decades. The elderly are expected to move to the more rural areas for a quieter and more affordable lifestyle (1). One commentator saw 'Uber-type' services providing an increasing alternative for those communities (1) – these communities may open up a market for transport in rural areas (1). The market will provide specific services to specific destinations for specific passengers, for example the elderly who will have different needs and destinations (1).

Shared in smaller areas

Shared transport and smaller scale options, the more demand responsive options, might become more prevalent in smaller metropolitan areas (1), or in suburban and rural areas (1). With less access to publicly-owned transport, rural areas are likely to see an increase in the use of autonomous cars as the dominant form of transport as they become more affordable to own (1). "I was talking somebody in Invercargill who said that he actually thought about replacing the buses, which were empty at Christmas, with taxi vouchers over that Christmas period which would allow the bus drivers to have a holiday as well. Everyone in Invercargill went on holiday, he said, at Christmas time and

they could identify regular bus users through electronic ticketing systems. So, as we can see, that technology may be used in all sorts of different ways” (Interview 16).

Looking at income-related markets, one common concern was that society was becoming increasingly divided and that this would have significant implications for public transport. One respondent stated, “The rich will always have their helicopters” (Interview 7). For everyone else however, if real estate in urban areas continues to get expensive, it will be too expensive to also own a car and so public transport in urban areas will experience even more growth (1). Some respondents think that there will not be much public transport choice in rural areas because it will be difficult to provide in areas without high subsidies to off-set some of the cost (2).

Another respondent suggested that the cultural and behavioural differences between rural and urban areas will play a part in how the two areas grow – there are big differences in attitudes towards public transport in these areas (1). They stated: “in London, a high-density city, there is a much stronger history and culture associated with using public transport than there is in say a town like Loughborough where the car is still king, so I think there will be spatial differentiation” (Interview 16).

Journey purpose will determine

Journey purpose can also be a useful differentiating aspect. Commuting will likely be made by high-capacity modes running into the city, and will be focussed on efficiency in terms of time and cost (1). But, as noted above, work hours are becoming more flexible and 9-5 may no longer represent peak travel times (1). One respondent suggested that a shock to commuting patterns, such as the death of aviation (as fossil fuels run out we will have no alternative), could have a huge impact on work patterns, and therefore travel patterns (1). Many rural residents have hands-on jobs, requiring movement between multiple locations (and sometimes off-road), which does not suit public transport or autonomous vehicles, so they will only be used over manual vehicles when necessary (1).

Travelling from rural areas to small centres may also change with a return to suppliers delivering goods to people, rather than people travelling to pick them up – we are already seeing this with the likes of ‘My Food Bag’ (1).

One final response provided a useful summary of the points above. “Passenger needs and expectations have already changed, as travel patterns are now more dispersed in time, space and function. These trends will likely continue. The present public transport systems are too focussed on the corridors, rather than on the huge potential demand outside those routes. Just tweaking the current product through lowering fares, raising frequencies or introducing Wi-Fi, will not meet these broader passenger expectations. A more radical approach is needed. If there is greater variety in the types of transport provided, then there will be a greater diversity of users” (Interview 8).

Passenger needs and expectations

Won't change

One commentator suggested needs and expectations won't change much in terms of how long it takes, cost, convenience and comfort. These factors may improve and draw more people to public transport and away from private cars or car ownership (2).

Less need for travel

One trend forecast, was that there will be less need for travel. This is because more things will be delivered, and because people-to-people communications will increasingly be delivered on line via audio conference and video conference (1). This fall in demand will lead to many services being scaled down. On the other hand, costs should fall due to automation reducing labour costs and more efficient, likely electric, vehicles being used. Only commercial services that make a reasonable profit, or services that deliver good socio-economic benefits for limited amounts of public subsidy, will be provided (1).

Power of the consumer

What came across strongly was the 'power of the consumer' in dictating what they want rather than what the operator wants (6) – what is available will be determined by what people want, rather than what is available (2). Passengers will demand higher quality public transport services (7), access to high quality and real-time information such as options, travel time, reliability and cost (6) and more seamless, integrated and electronic interfaces (4). These expectations could stem from the experience of more mature and innovate public transport services overseas, whether that is physical experience, or what people see on social media or the television, etc. (2).

In a future where automation increases the attractiveness of private transport, public transport will need to provide a personal car level type service to compete; that means they will need to take passengers from where they are, to exactly where they want to be (1).

An aging population will bring challenges; some of these will be related to transport accessibility. Passengers will expect to be able to access their mobility easily, which will have implications for transport design (1).

Operator incentives

Some commentators thought that while customers will have more power, the operator can provide incentives for customers to make a small concession that benefits both the customer and the operator. For example, the operator may know the customer wants to be picked up, but the operator tells the customer, if you walk 400m, your pick up time is 3 minutes less and you will save 10% (1).

It was also suggested that consumers will expect these incentives and rewards, especially where they are choosing public transport rather than driving (2). There will be a greater civic responsibility where everyone collectively realises we have been doing things dumb and we need to do them differently to achieve a better outcome individually and collectively (1).

Conversely, one respondent thinks that public transport will not bend to the consumers demands, and instead will continue to get as many people on board as possible (1).

Turn up and go

Dominant paradigm: passengers will want to just turn up and go

Increased frequency of services were among the top passenger expectations. Passengers will just want to turn up and go, and providers will meet this expectation (11). People will expect the public transport system to react to us, particularly when armed with more information through technology (3). There will still however, be an expectation that real-time information is available, and people will use that for certainty that their service will arrive on time (3); reliability problems are inescapable, even with automation – glitches and breakdowns are still possible (1).

Further to the idea of real time information, it was suggested that the accuracy of that information will allow mobile phones, or other personal devices, to set alarms or reminders based on the information it receives (3). An alarm in the morning could sound after taking into account how far away the particular transport mode is, how long the commute is, and how long the user needs for breakfast.

More flexible

Less rigidity and more flexibility is likely to accompany more frequent services (1). People will expect transport in the way they want it – they want the end to be at their destination, not at a stop 100 metres away (1). One respondent thinks that because of this increase in consumer demand, people will be more impatient and faster services will be needed to satisfy demand; a pricing may be used to create a priority service that is easier to manage (1).

Personal space

Some comments were also made as to the increased importance of personal space (3):

- there is a strong possibility of a U-turn in terms of social and lifestyle needs, whereby people might actually like the sociable aspect of being on public transport, and may want to be around other people (2)
- increased desire of social interaction will likely mean very little change in peoples expectations of travel (1)

Conversely, another respondent suggested that passengers will increasingly demand personal space. This will become more likely if there is some kind of health scare, such as a super bug and anabolic resistance (1). The division between the rich and the poor was also discussed, with the gap anticipated to grow, and for “attitudes of the rich to demand separation from the poor “ (Interview 50).

There may also be more emphasis being placed on the idea of time on public transport being considered more ‘useful’ than time spent driving and a means of fitting more hours into the day (2). This will most likely be accompanied by a demand for Wi-Fi or other ‘useful’ or comfort services (2).

Differentiation of services

The operators response to these demands were highlighted, with many suggesting that operators will differentiate their services and products to meet different passenger needs and expectations (5). There might be a premium, standard, and no frills differentiation in services, which will be priced accordingly (4). Additionally, there could be more services dedicated to providing transport for particular groups, such as the elderly or disabled (1).

Alternatively, if your style is an expensive car you might belong to an expensive car-sharing service (1). The allure of private vehicle ownership is you own bubble of private space so if public transport systems can incorporate private spaces, such as smaller carriage sizes or small compartments, they will most likely be more popular (1). There will be a greater focus on personalisation whereby the user is in control (2).

Several security issues to be resolved were highlighted regarding the user experience. Security in on-demand transport will need careful management (1). With the advent of car-sharing and other similar schemes, people will need to be reassured that they are hopping into a smaller vehicle with someone they are comfortable travelling with (1). There is likely to be a dramatic increase in CCTV, and people could be banned from various types of transport for previous offences (1). There lies a barrier to acceptance of a more efficient system, unless security concerns can be overcome (1).

Transport system stakeholders

There were many different ideas as to who the transport stakeholders might be, and how they would interact. It was hard to determine a clear dominant theme here due to the wide variety of suggestions and ideas.

Wider range

Transport planning will involve a much wider range of actors than in the past (11). This will challenge traditional private and public operators. For instance, the financial services and technology sectors could become very important, and they will bring new business models (5). This will mean that new alliances will have to emerge and hence ways of delivering transport are likely to change (1), this will make it harder to plan the system (1). Financial service companies will be more attracted to transport, the more consumer orientated it becomes (1).

New partnerships and business models from existing companies

New partnerships will have to develop to provide the right services, such as car-sharing or UBER-style transport (2). The private sector will lead experimental partnerships to deal with the messy transition; there will be a need to persist with addressing any challenges along the way to create success across the system (2). These could result in a more collaborative public/private relationship to provide public transport (1).

Leasing may become a more popular ownership model as the capital costs of purchasing a vehicle can be recovered through operating costs (1). For example, “[Volvo, for their hybrid buses are leasing batteries because the upfront cost of the batteries are so high they actually lease the batteries that turn capital into an operating cost](#)” (Interview 41).

Large companies, such as traditional public transport providers or current car manufacturers who may go out of business, will start to adopt new business models, including providing mobility – these will be companies like General Motors, BMW, etc. (5). “I think we’re going to see the reconfiguration of various industries into new consortia I guess and mega companies that are capable of delivering these information technology mobility solutions” (Interview 11).

“Traditional car companies, for example, will have to reinvent themselves dramatically, if there is a change in ownership and a change in vehicle designs, cos then all their big advantages of being able to buy steel at a cheap price or whatever is not important anymore” (Interview 49).

Decentralised

Transport operations will become much more decentralised with a lot more companies involved in transport that may not provide the direct service, but may provide insight, data and information to the people that provide the service (1). Companies are also likely to compete to offer various transport services due to the vastly reduced cost of doing so, and the security and safety enabled by connected technology (1). Whoever thinks that they can make money out of transport services, will be able to operate, whether they are a small or large company (1).

More entrepreneurial/ UBER style

There will be more Uber-type services, which will be more innovative and entrepreneurial, and under a lot less regulation (3), this means a lot smaller outfits and services providing on-demand services (8).

There were a number of suggestions as to how this could work:

- there could be small businesses that are dedicated solely to driving employees to work, as we already see in California (1)
- there will be many more of these operators that are niche driven; diverse operators that are providing services to particular markets and sub-markets (1)
- there may not be a need to gain traffic operator permission by 2045 as services will develop to meet a market need, and the market will dictate whether they are popular or sustainable (1).

Respondents also made suggestions as to why we will see more smaller transport stakeholders:

- the rise of the sharing economy will allow for the rise of sole traders and single businesses anywhere (2)
- there will be a reduced need to move from an urban centre to a centre of business and instead see a lot more intra-urban movement (1)
- vehicle owners could make their vehicles available to others when they are not using them, on a wider basis than currently – this would create mass small-scale transport providers (1).

Individuals will be able to become a type of operator themselves: “I think we’re gonna still have large multinational private operators that provide transport services, in areas across the world. I think that we’ll probably still have some localised operators. I think that we’ll get a massive increase in the number of individual kind of providers of transport services - somebody who owns an

automated car who's quite happy to let that serve as a pod in a vehicle fleet in future" (Interview 49).

Operations contracted out

Dominant paradigm: public transport will be contracted out to private operators

The most agreed upon view was that public transport operations will be increasingly contracted out to private operators in most places (7), one respondent thinks it will be easier if they are single operators, or small companies (1). Alternatively, there could be a set of global companies operating public transport systems in various cities around the world (3). These global operators will bring in lessons learned from other jurisdictions, and will be experts in communication, data management and integration (1).

Another respondent thought that there would be more private involvement as the public sector lacks the skills required to operate services after such a long period of deregulation across the world (1). Even if it is possible that the network provider role will be franchised out to private operators in the future, it is likely that larger operators will predominate after an initial period where new technologies are pushed by small, innovative entrepreneurial operators (1).

Large, private operators benefit from economies of scale, an advantage over most public sector organisations, so they are likely to run the services, but within the overall, regulatory control of the public sector (1). Conversely, if the driver is removed and autonomous vehicles are prevalent, public bodies may see value in owning the vehicles and therefore becoming the operator (1).

Fleet owners will emerge

Some respondents are of the view that fleet owners will begin to emerge, such as Google or Uber, who offer shared autonomous car fleets for public use (6). Another agreed with this, suggesting that this will be the reason for less public involvement in delivering public transport, and that these fleet companies will look similar to a telecommunications company (1) – "that used to be part of the public structure, telephones and post offices used to be one combined entity" (Interview 26). Alternatively, another respondent can see "a few large fleets, privately owned, that would be under careful contractual service agreements with the centralised hub" (Interview 39).

Slightly different, one respondent saw more private ownership and investment in transport coming from the car industry who will be looking to protect itself from the coming changes; instead of dialling Google for a car, you will dial of a Toyota or a Hyundai (1).

Public control

One respondent suggested that government versus public control could go two ways. "Either the public bodies will say actually, we can do it all, there's nothing stopping us doing all of this efficiently. Or, they will say, well why don't we unleash the potential innovation of the private sector and see what more they can do, and we'll provide a framework for that to happen" (Interview 18).

A respondent working in the transport public sector, thinks that "ownership around vehicles and infrastructure will move away from private to public, but there's no reason why the operations and the service management can't continue to be provided by the private sector" (Interview 34). Another feels it will all depend on whether the public purse is required to subsidise public transport.

In addition, if it does, undoubtedly there will be government, whether it be central or local, involvement because it is involving public money (1).

Additional points were made on the subject of new partnerships and business models:

- the current model, where private operators deliver services, is not successful or efficient; the future will see operators as an extension of what we have now, but with stronger involvement by central and local government in the process (1)
- the businesses that are going to excel over the next 30 years are those that can find efficiencies through data and insight – they will have more information about the problems that were previously thought to be unsolvable (1)
- whether businesses are fit to take the role as a central control unit, or whether government will use or purchase this information to keep control, is unclear (1)
- innovative ideas around ride sharing, car sharing and bicycle sharing show that people are doing things for themselves and, as a result, there is less of a need for an individual operator such as a bus company or local authority (1).

One respondent suggested that how vehicle manufacturers respond to Mobility-as-a-Service (MaaS) could be quite different to what we expect. We are already seeing alliances between different players, such as Amazon and Ford, so different business providers are likely to combine and offer services (1). There may be social equity issues associated with this, so regulation may require those types of service providers to offer services to complete the network, rather than where they can make the most money (1).

Mobility managers

The idea of a ‘mobility manager’ came across in an Interview as organisations or operators who manage, organise and control all mobility in a city, or parts of a city, with a strong oversight of delivery, contracts and service quality (2). These organisations could be public, private or a combination of both (2). A fully integrated system will be hard to manage at the local level, so one respondent suggested that central government will be best placed to manage the entire network to ensure systems and jurisdictions talk to each other (1).

Another respondent noted that there needs to be an operator capable of delivering high capacity, frequent mass movement as separate to the point-to-point, more flexible, operators. The more flexible operators could include one big system provider, such as Uber, or several system providers who are competing to provide the services (1).

Does not matter

Some respondents felt that it actually would not matter who operates public transport. Reasons for this included:

- as long as there are effective criteria, specifications, and incentives in place to create the ‘right’ system (3)
- if all vehicles are autonomous, then it would likely be a central organising computer, either government run or privately run (1)

- a range of private companies that individually run their autonomous services – but ultimately the service is running and meeting the public’s needs, so how it happens is of no concern (1).

Another respondent does not believe that the system will change much, in terms of who operates it. Absent a disruptor, the systems around subsidy and governance are highly invested in, as they are (1).

Another respondent felt that there would need to be some kind of ‘license’ or authorisation process to provide services, to ensure that the system remains balanced and provides the right services. Outsourcing completely would leave a number of responsibilities un-tended and the service could lose its reliability, serviceability and maintenance – the short-term options could undermine the long-term infrastructure. People could say one thing and do another, which would run the risk of a lop-sided and un-maintainable system, possibly even a bankrupt one that cannot afford to the upkeep of infrastructure (1).

The roles of local and central government in 2045

It was clear that the interviewees saw the roles of both central and local government in 2045 as being different from today. There was a clear consensus that innovation in the transport sector will be important in developing the future we will have in 2045; there were however, a number of different ideas as to how the government will encourage this innovation.

Government as a planner

One respondent saw government’s role as being tackling the value versus volume question. For example, *the value of people walking down Lambton Quay in Wellington is far more significant than the volume of single vehicles on the road on Lambton Quay. Therefore, “you could argue that actually your best marginal dollar is related to improving the value of people’s movements, versus the volume of traffic movements”* (Interview 44).

There also appeared to be a planner role for local and central government (1); they will be planning and securing the resources and infrastructure required (3), as well as providing incentives and requirements to develop services that meet needs and fill gaps missed by the market (2). This may also include planning how vehicles and infrastructure will interact with each other (1), or how many vehicles will be needed to best serve demand (1). Increased availability of data was seen as key to improving how public transport is planned and organised (2).

Dominant paradigm: government will be a manager and a regulator

Government as a manager

Many thought that the roles of local and central government will be a move from infrastructure, finance and risk management functions however, to being more about managing private community and public actors to deliver projects and services, and reduce public transport costs, as ‘enablers’ (7). This idea of government acting as a ‘watchdog’ came across strongly (4). The managing role for central government also came across strongly – transacting with network suppliers, managing policing and managing of data and protecting safety (2). A stronger need to be involved in decision-making was considered necessary for an efficient and successful system (3).

- There is a strong rationale for the public purpose, the public interest to have coordinated and centralised information systems across all modes – so public bodies may turn into ‘mobility managers’ dealing with all modes and being impartial in offering passengers a choice in travel (1).
- Individual providers could lead to an uncoordinated system, which is good from an innovation perspective, but bad from a co-ordination perspective – so there is a role for government in striking this balance (1).
- Local and central governments control of the core network, that will remain because they own the land on which the network operates; service provisions however, will be more commercial to promote competition (1).

Others were unsure as to whether the public or private sector would deliver mass transit in cities (1): local government will be about ensuring there are sufficient opportunities for movement; but, if there are a number of mobility services providing different service offerings, then there is less need for central provision (1).

Another respondent felt that central government would be managing the “soft and hard infrastructure”, but was less convinced about local government’s role in the provision of transport: “I think if the centralised government entity owns the control system and all the providers of services plug into that and customers can dial it up and plug into that, and also maintain the roads and the rail networks, local government’s role is not really that evident” (Interview 39).

Government was also seen as managing ownership and organisation:

- public transport will be privately owned and managed by 2045 (4), but, road administration may shift from being controlled on several layers, to a more simplified structure for government to oversee (1) – this would allow for the introduction of new types of dynamic road management, and even regulation.
- technologies and their development are hard to predict, and therefore it is difficult to forecast what government’s response will be in terms of ownership (1)
- government will manage private providers contracts – “they will need to be long-term to allow for significant investment, otherwise we will end up with a situation like before PTOM, where operators didn’t have certainty to invest in vehicles or services” (Interview 43).

Government as a regulator

There was also a consensus that the government may have no role in the actual delivery of transport, other than regulation (6). Several reasons were given for this:

- the main purpose of transport regulation will be in organising the transport system and balancing flows, rather than the provision of roads or provision of public transport (1)
- the government will need to regulate to ensure that services are integrated, even where there is diversity of services and provision (5)
- current regulation is not fit for purpose – new interactions between regulation and technology and innovation will require substantial changes to regulation over the next 30 years (4)

- regulation will have to keep up with technology development (2); part of this will be about providing the enabling framework for business models and entrepreneurs to come into the market while maintaining safety and security for the network and consumers (9)
- the government might create tax breaks for small companies – this could be incredibly beneficial, and a powerful incentive, if a company is able to solve a problem that the government has traditionally been unable to tackle (2)
- the current bus-operating model can potentially stifle innovation, so there may be a move back to less regulated public transport to enable flexibility, rather than having contracts and specifications rule everything (2)
- there is currently no scope for product or service differentiation, so the ability to do this would be important for the future (1)
- As an example of how new regulatory regimes might work, another respondent anticipated that rather than the government indicating where a train network will need to be, it will work with communities and private companies to solve the problem that the train was intended to fix – this will create more flexible solutions to transport problems (1).

Some respondents believe that government needs to look at increasingly getting out of the way of innovation in the transport sector, and take up more of a facilitative role instead (2):

- facilitating would allow businesses to find solutions to problems, rather than the government doing so; it will be more of a collaborative effort, rather than prescriptive effort in the future (1)
- consumer demand will change a lot faster than a government can centrally organise, or design, to solve that customer demand; therefore, government will need to put a lot more trust and expectation on the market to provide solutions to those problems (1)
- the top-down nature of government needs to be less risk-averse, be more courageous and embrace innovation (3).

There was a suggestion that if the government made the decision to let the market shape the transport system, then big companies like Google, would have the ability to become the dominant provider – government has the ability to decide whether it will become the provider itself, or whether there is another option that will create a more efficient system (1). Making this decision would allow the government to prepare for whatever particular future is coming. One respondent noted the problems with market regulation in low density areas: [“New Zealand would fall into this \[low density\] to a large extent, is that the market may not be such as to sustain commercial competition on all routes, so you may have one incumbent operator most of the time, perhaps with the periodic threat of competition” \(Interview 12\).](#)

There were a some suggestions as to how the regulation might change:

- the current regulatory framework is not well adapted to deal with private providers becoming dominant, as the current focus of regulation is on welfare, this will need to change (1)
- regulation will decrease, and there will not be prescriptive regulation that tells operators what they must do (1)

- regulation won't change much, it will instead react to problems, rather than create an expectation or guess what will happen (2)
- if something goes terribly wrong, there may be a political knee-jerk reaction and regulation will get tighter - there is a safety trade-off on how prescriptive regulation is (1)
- by 2045 there will be more flexible labour markets as unions fall away, due to an increasing focus on individual consumers, this means operators will be able to provide more flexible services (1)
- price regulation will not need much attention from government, except in the areas of public transport with only a few operators, to prevent collusion; in areas with lots of new players, it is less important (1)
- there will no longer be a need for driver regulation, as the driver will be removed in an autonomous vehicle, regulation will instead focus on safety and security (2)
- integration and compatibility between vehicles and networks, particularly regarding standards such as radio and cell phone networks, will be a new element to safety regulation (1).

Government as a funder

One respondent saw funding as being central to how the roles of government would be determined. "It all depends on funding arrangements; whether it requires a subsidy and where that subsidy comes from. As it currently occurs, a subsidy is more or less 50/50 between local and central government, and of course, both organisations want their hands on the levers because that is how funding works, I guess. If the way funding changes then I think the roles will change with that funding" (Interview 18).

Further discussions regarding local and central government funding varied from who will be providing subsidies, to who will be investing in the infrastructure required for transport in 2045.

As noted in a previous comment, it is expected that the government will supply and own infrastructure and resources, and contract out the services (5); there will always be a role for government funding to some degree, because that is the way it has always been and that is the way it will be expected to carry on (1). However, there were some concerns as to how that funding would occur, if there is no longer any excise tax on fuel being collected (with the advent of electric vehicles) (1).

A number of other reasons for government maintaining a role in funding were also given:

- the development of new transport services will be affected by the provision of infrastructure, particularly capital works for both private and public transport (1); a strong focus on infrastructure will be required to allow room for growth and simulation in the transport sector
- top-down government investment and infrastructure provision will be replaced by systems that are more responsive and adaptive to demands (1)
- when the New Zealand fleet turns electric, new funding mechanisms will be required to compensate for the loss of fuel tax (1), and that perhaps; government will need to pay or reward people for using public transport in order to balance the network load (1)

- new types of revenue streams will need to be exploited in 2045(1) – subsidising public transport with parking revenue, workplace-parking levies, or congestion charges could be explored, particularly in urban areas where people can see the benefits of good public transport (1)
- government will need to take more control of charging and investment, especially as electric vehicles increase in uptake and fuel taxes no longer work (1).

Others saw governments role as determining subsidies, and who would be eligible for those subsidies:

- the government will determine subsidies and enforce who is eligible for those subsidies (2)
- government subsidies could be challenged if a situation of over-competition develops (1)
- “the current competition framework is deficient and would not prevent a global company (like Facebook or Google) from buying up the little firms and becoming a dominant player, which would then dramatically alter pricing and competition in the system” (Interview 46)
- over-competition could lead to competitors under-cutting each other and reducing service levels (1)
- shared transport will reduce the need for public transport, but that ignores the fact that public transport is subsidised. There would need to be a massive swing in popularity of shared transport, and ensuring all shared vehicles are well-utilised, to threaten public transport patronage (on a cost-basis); subsidies exist to encourage the use of public transport (1).

Additionally, some respondents still noted a role in which the government financed transport in some way, though not in the same way as it does now:

- central government might still distribute subsidies for capital investment, but actions at the local level will be crucial (1)
- there could be less investment in the longer-term projects because of the increasing uncertainties as to what the future may look like; instead, cheaper and shorter-term investment solutions will become more attractive (1)
- government could use investment to attract more people to public transport (1)
- government could use road pricing to develop a pool of funds for investment into better public transport (1).

Alternatively, there will be less involvement from central government:

- as farebox recovery increases, the need for subsidies will decrease (1)
- the market will take control of the subsidy issues, so Government won’t have to subsidise public transport (1).

One commentator suggested that there will be more devolution in the sense that local governments will control their local areas and provide transport that is specifically suited to that area; this will require local governments to raising money for local systems (1). Linked to this, is the suggestion that “subsidies should be based on the value of the city or local area adds to the national contribution – so the more value they add to the country, the more subsidy they will receive” (Interview 6).

Government as a provider

There were several views on governments potential role as a provider:

- councils are more likely to use autonomous vehicles as a shared form of contract or fleet providers to complement their mass PT by serving the low volume or low demand routes or time of day (2)
- cities could end up playing a much bigger role as a mobility provider by owning fleets of vehicles for a range of mobility purposes, and in a range of sizes, propulsion, control, etc. (1)
- if more infrastructure is needed, particularly around automation and rapid corridor, the government will need to take a more active role in the provision of these services – they will require greater investment, greater coordination and integration, control and regulation (1)
- there will be provisions that are missed by the market, possibly because they do not make as much (or any) money, and the government will need to facilitate these provisions or fill the gaps in the market (2).

Conversely, another respondent feels that if public demand increases, some local councils will struggle to pay for the required infrastructure (2) – we have seen in Auckland, the government coming to the party for the central city loop (1). There will be a call on central government funding for more local public transport; with that role, central government will have more of a say in how local government is administered (1).

Some respondents were unsure what the government's role or policy stand would be in 2045 (4). It was still thought to be important in the overall make-up of the transport network (2), and that as these things begin to come down the pipeline, we will get a clearer picture of what the government's role will be (1).

Government structure in 2045

Interviewees also discussed the structure of local and central government in 2045. There was a general consensus that local government will play a very important role in planning public transport (2), which is the only way to make sure it is completely integrated (1) and planned and organised to meet local needs (2); it will allow a more holistic approach to transport and multi-modalism in local areas (1). If there are more unitary councils, there will be greater efficiency and better decision-making in the provision of service (1); the current regional council structure is weakening, suggesting a move towards unitary councils (1).

Similarly, it was suggested that government might need a stronger role in co-ordination and integration between systems and between jurisdictions. There is also a national interest in being integrated with other countries, such as enabling integrated systems between Sydney and Auckland, for example (1).

One respondent felt this question was difficult to answer due to all of the variables. It will depend mostly on the political stance and public finances in 30 years time (1).

Factors influencing change

Dominant paradigm: a range of factors will influence change; the factors we cannot predict will be the most influential

Technology

In terms of factors influencing change, there was a general agreement that technology and several secondary impacts of that will play a large role. Technology, what ever that is in 2045, and the social aspects around it, will shape the future system (11); it will presumably be able to provide solutions to transport problems (3) and remove negative externalities such as environmental or social equity issues (1), although there are still likely to be problems that remain unsolved (1). While self-driving vehicles should be used, if the technology is safe (1), to open travel opportunities for people who are currently constrained (2), there is still the possibility of creating more congestion by putting more vehicles on the road, highlighting the importance of corridor transport (1).

Some key thoughts around technology as a factor, are as follows:

- “The most important change will be the shift to private and public transport being automated by 2045” (Interview 7).
- labour costs will also drive increasing automation of trains, for example – any action that will optimise efficiency will be taken; this is a technological driver working in conjunction with economic drivers (1)
- the amount of information the system collects and uses will make a big difference to the transport system in 30 years time, but it is difficult to know to what extent, or the scale of the impact (1)
- human ability to exploit the full benefits of technology might be a barrier to its true value (1)
- “technological developments over 30 years are going to be astronomical; effectively, think robots – robot everything” (Interview 50).

Technology was seen as an ‘enabler’ for public transport (6):

- it will help us gather data see where people are and link them together (1)
- it makes something more attractive than it previously was (1)
- more informed transport choices will be made with the information that will be available through smartphones (1)
- technology will need to be embedded in infrastructure to capture accurate data sets, inform the overall design of transport and provide helpful information (1).

Virtual reality was also mentioned as something that has potential to change travel as we know it:

- there could be a tipping point with virtual technology where the quality of experience becomes a substitute for travel (1)
- it could, at the very least, increase the flexibility of connecting with people (1)
- “technological advancement and the sharing of ideas internationally and increasing globalisation will support the acceleration of technological, not solutions, but transport alternatives. So we have the capacity to learn and adapt quickly using overseas capacity, both financing and technology and skills. Therefore, we could have rapid change, which we already do have really. International trends will be quite important.” (Interview 15)

Political and Legal factors

A number of political factors were thought to play into whatever future we are experiencing in 2045. There are legal and regulatory issues with direct effects, as well as the swing of political colours that will determine Governmental priorities.

In most cases, it was suggested, the legal system is going to be playing catch up with technology (5). Governments will need to ensure that legal frameworks will remain effective (3), particularly for how and where driverless vehicles can operate (4). There will be a need for legal frameworks to be more proactive to keep up with technological changes (1). There will be a need for new regulations to prevent people exploiting the system for negative ends; for example, what measures will be in place to prevent people from stepping out in front of autonomous cars with the intention of making them stop, and thus interfering with the overall traffic flow (1)? Legal frameworks will have to find a way to deal with how autonomous vehicles cope with random events, such as where the liability lies in the case of an accident (4). Additionally, there will be a political element in using surveillance technology – will people want the benefit of the technology where there is a cost of personal privacy (1)?

The political element was considered a hard one to sense, the change in government that occurs every three years creates a number of uncertainties (1) – this could affect transport itself as well as factors influencing public transport, such as urbanisation, migration and demographic behaviour (1).

Other political factors were also noted by respondents as being likely to affect the development of the transport sector:

- we will see a much greater level of acceptance amongst politicians that public transport is a viable option and solution to many congestion and mobility problems (1) – this may be a catalyst for other growth factors (1)
- road pricing was determined a political factor with the potential to influence change. Political will is needed for government to use road pricing to charge road users for the external costs they impose. Government could use the pool of funds created from road pricing for investment in public transport, this would encourage a shift towards public transport and away from private transport. There has been international opposition to road pricing, yet a similar concept applies to our mobile phones, so while demand pricing is currently politically unpalatable in transport, we may see this changing over time (1)
- political preferences and decisions, will have an impact on transport, for example, whether the transport sector is market driven or whether the government takes an interventionist approach (2)
- as the international market begins to flourish, big ‘political fights’ are anticipated around the world, regarding who owns what resources (1)
- “New Zealand will want to remain competitive and cohesive, which will require access for all citizens to mobility and transport” (Interview 39)
- politics will be more concerned with those big core services, but they will continue to shrink in proportion to the total services provided (1).

Conversely, some respondents suggested that in fact political factors will not have a significant impact on public transport development in New Zealand (2). The same political ideologies regarding

a 'hands on' or a 'hands off' approach from government will continue, which will result in little political change (1).

Social

Social factors were also considered important in their own right.

Urbanisation and where people are living was mentioned as a factor for change:

- the social desirability to live, work and travel in certain ways and the re-urbanisation over the last 15-20 years, has been all about people's changing desire to want to live in urban areas (2), and this won't really change (2)
- the population balance between cities and towns will be a big driver in determining where the money, and the investment, goes (2)
- the elderly, as well as the young, want to be in urban areas – elderly move to the regions for a quieter lifestyle and find they have nothing to stimulation them there; this form of urbanisation has it's own implications for public transport access (1)
- conversely, there could be a big change in lifestyle choice by people who are wanting to live further away from the city – they will tolerate long commutes, although those commutes could change drastically through autonomous cars, road pricing, and making use of travel time – so there will be significant pressure to expand infrastructure outwards to reach these areas (1).

Population demographics are also expected to play a role in public transport development:

- the aging population is expected to have a huge impact, as will millennials and their travel choices and mobility needs (5)
- aging populations and difficulty retaining rating bases and job due to automation, were all suggested to have profound effects on transport and restricting mobility, particularly for those who cannot afford it – wealth inequalities are going to remain high (1)
- millennials, and younger generations, have the opportunity to grow up without the social stigma currently attached to public transport; we are likely to see an increasing social acceptance of public transport over time (2)
- the young versus the old, and who the public transport system should cater for, was also raised as a driver (1)
- health issues are very entwined with our transport systems (1)
- compulsory school ages, composition and hours will affect peak travel and demand (1)
- the level of coherency within income levels, ethnicity and wealth will play a role in the development of transport systems (1).

Changes in gender roles were also mentioned, although with a caveat that it may mean little for transport development. Women have higher levels of public transport use than men (2). The gender shift to women and their earning power will continue and there will be major cohort shifts in this regard (1). Social changes such as same sex marriages, while not directly changing transport, will change household structures (1).

In terms of social engagement, there was a small split in opinion of whether people will still travel to each other, or not:

- it was suggested people will increasingly be working from home, so there will be more flexibility in when people need to travel (1)
- if the traditional work day, and even nature of work, changes, this will affect transport (1)
- there will be an overall reduction in travel (1)
- physical travel to see other will decrease as digital means will provide a mechanism for socialising instead (3)
- as society moves towards a more individualised mindset, being part of a group is expected to become less important (1).

Alternatively, there was a view that people will still want to gather en masse to attend public events, so mass transit will still be popular (1).

Population growth was highlighted as being a very important factor in transport developments (2). People will expect highly efficient, environmentally friendly rapid transit with very simple access; this will need to be catered for in the context of a larger population (1). Immigration and immigration policies in particular, will have a large impact (1). Ultimately, as the population grows New Zealand will experience densification, of which public transport will play a huge role in maintaining efficiency (1).

Linked to these comments, is the idea that social change has the ability to change both social and political goals:

- social norms are strong drivers, which have a political influence too – for example, it is difficult to make people share a private vehicle with strangers (1)
- politicians will shape their ideologies around the make up of society to win elections (1)
- ultimately the public transport system will be driven by the demands of the people (1)
- development will be about listening to the people and communities and that will drive regulation, policy and technology (1).

One commentator pointed to the nostalgia of having traditional materials, items and transport. So, while autonomous vehicles may have many benefits, people may feel more comfortable with older technology for their nostalgia, comfort and heritage value – it will require a leap of faith for some people to do away with the traditional technologies (1).

“The context remains that humans inherently want to minimise the energy which we expend, both in physical movement and in mental tasks. Humans will always look for the easy option. Humans are also short term, optimistic and forget – so even with major events, humans, over a relatively small number of years, revert to their former behaviour” (Interview 1).

Economic

Economic drivers centred mainly on investment and the effects of autonomous cars.

- Economic triggers are anticipated to determine transport pricing, planning and provision (4).
- One respondent suggested that there needs to be significant investment in satellite technology to fully realise the benefits of autonomous vehicles, and prevent adverse safety outcomes (accuracy needs to be in millimetres, not centimetres) (1).

- Funding constraints, we pointed to as a significant driver, just as much as the physical and geographical constraints (1).
- When autonomous vehicles become cost effective, people will switch over from manual cars (1).
- The vehicle fleet will be reduced by around 80% as autonomous cars will drive multiple people around, while others are saying that road capacity will need to double because autonomous vehicles will be making two-way trips, instead of one-way (1).
- The growing economic power of cities will also play a part in the development of transport (1).
- Public and private debt was not expected to change greatly from today, and neither were the limits to world growth – if anything one respondent saw it getting worse, which would limit the investment that could be made in transport (1).
- There is going to be a much greater flow-on effect into our economic future from cities, but cities will need to be accessible and public transport is a great solution for that (3).
- Moving more people around a city and improving access to a city, will be used to develop the city in both a social sense, and in an economic sense - so we will see the value of public transport improve over time (1).
- There are big things that are out of our control. Maybe a collapse of global financial systems, etc. These will influence the way the country is run (1).
- Wealth disparity will affect the development of, and who will use, public transport.
[“Economic and social implications are already starting to become manifest – you are seeing a gradual division of the haves and have nots with a huge amount of pressure” \(Interview 50\).](#)

Environmental

Environmental factors came across strongly as contributing to the development of transport. People are expected to have more of an environmental concern in the future (8).

These factors included unexpected events or disasters:

- one respondent noted that a few big environmental shocks would have a profound effect on society and mobility, such as drought, tsunamis or other extreme events (1)
- climate events could also be included here, which also goes hand-in-hand with the expectations that people will have around how those events should be handled (1)
- society could despair at ways to avoid environmental collapse as sea levels rise, we experience stronger climate cycles, starvation or even war, and these things will destabilise the world, which will have a dramatic, sweeping impact (1)
- over the course of 30 years, there will be catastrophes, and they will have a huge influence on what developments occur over that period. [“These could be natural disasters, epidemics, wars, weather crises, crop crises, food shortage, or antibiotic failure – looking at any 30 year period of history, the big things that have shaped it have been these catastrophes, or sometimes, things like the industrial revolution, which we are *still* feeling the effects of in terms of technology and environmental degradation” \(Interview 23\).](#)

Climate change and environmental goals will play more of a role in the future:

- actions to mitigate climate change could shape our transport system (4), particularly if the price of fuels change in response (1) – governmental response is a big uncertainty at this point, and it could have a large effect on transport (1)
- environmental goals will become more prominent as politicians try to please the people and win elections (1)
- public transport, and the challenges of managing continuous transport infrastructure, will play a huge role in meeting environmental goals (2), especially where infrastructure was built for a more stable climate (1)
- transport will need to be more resilient than in the past to deal with climate change and its effects (1)
- environmental concerns will become a lot grittier as environmental effects and climate change become more important (1).

Carbon concerns might shape the future transport system:

- Carbon tax may become more likely as a method to balance the use of different modes, especially as carbon becomes a concern of the wider society (1)
- Global population increases mean we will have to do more with less, which means pricing mechanisms are likely to be trialled with a range of more diverse methods and tools than we have today (1).

New technology developments are expected to benefit environmental goals:

- Electric vehicles and autonomous vehicles using more space, more efficiently, and reducing fossil fuel dependence will help the move towards electric vehicles (4)
- as people are becoming more conscious of environmental outcomes and sustainability, reduce car ownership and increase the use of a shared-use model (1)
- local environmental issues, such as air quality, water quality and road safety, will become more prominent (2).

It was suggested however, that environmental factors won't be as big, instead better environmental outcomes will be part-in-parcel of improved technology (1). As fossil-fuel shortages become more starkly felt by 2045, alternative fuels will become the focus of many new technologies, and drive development (1).

The future of public transport – interesting quotes

Over the course of 50 stakeholder interviews, it is inevitable that interviewees will provide you with interesting and thought-provoking quotes – some of which may not have crossed your mind before. Below is a small collection of interesting points made by some of our interviewees.

In summing up and looking to the future of public transport, one interesting statement was that **“the public transport sector might declare Mobility-as-a-Service (MaaS) as being public transportation, declare victory, and move on. However, MaaS is not really public transportation in most cases... In actuality, public transportation is going to be in a worse position than it is today, because the alternatives will be so much better”** (Interview 7).

Interview 6 contrasted this by saying “the way mobility as a service is priced could incentivise use of mass transport over individualised transport” (Interview 6).

“In the end I think congestion will always play a part in any larger city, and so we’ll always potentially look at using that limited corridor space, you might call it road space now, whatever it is, it’s a corridor for transport. We will have to manage that in the best way we can, which is likely to mean in many places that higher density transport options would be favoured and given favour. Certainly public transport will exist in one way or another, but it’s likely to be spread a little bit more between smaller vehicles and larger vehicles because both vehicles’ capacity can be better tailored to the demand on the day and the time of the day. Because of all our technology, we will all know when to travel, where to travel and it will be more door to door, and at lower level door to station” (Interview 18).

“I think hugely important is whether government takes a policy stand on it and thinks it through, and says this is coming down the pipe anyway and we need to make sure that we’ve got sensible regulation in place to make it work better. So that’s going to influence which end of the spectrum it goes to, I think if we just leave it *lassiez faire* people will buy autonomous vehicles and they will have them drop the kids at school, and have them pick up nana and take her to her appointment, and do all those things that actually will increase the volume of traffic, the volume of VMT.

So what drives it in the other direction is encouragement of fleets, encouragement of investment in trying new things that help to shift the populations view from one way of doing things to another. I think that requires as much as anything, a strategic policy-setting stance rather than a: “hey guys, here are all the different outcomes that are likely, and let’s see which one happens”.

So that’s what I think is the most likely driver, and I suppose the other thing is the price points, if we see autonomous cars at \$20,000 without having done something to encourage fleets to develop, that that will be a problem, because you will just see a very large quantity of them out there and operating, obviously the regulation that allows them to operate will be important. I think once they are there and they are operating, and they will have proven their safety record, and their efficiency and effectiveness, I think the regulation that keeps them off the road will disappear pretty quickly, and that’s why there’s a need for strategic response to push it in the direction of heaven rather than hell” (Interview 26).

“I think we are, I look at America and there is not a huge reliance on public transport. But what we have seen already with ride-sharing services is that ride-sharing services are eating into the sales of private motor vehicles. So, right now, private motor vehicles are being used for most commuting in this country, and so ride-sharing services are going to change that. Cities like Washington D.C., New York City and so on, more and more commuting is being done using ride-sharing services. So, I think they are the changes we will see, so in American cities that don’t have a lot of heavy PT available, then these automated shared service will take over from commuting that takes place in private vehicles with single occupancy, which is still so prevalent, still so common. We are going to see a big change in that” (Interview 20).

“Yes, when you introduce autonomous vehicle technology, you may realise a capacity improvement on the private vehicle infrastructure – I don’t believe, as we’ve seen historically, that that will last forever. I think it will be utilised very quickly, therefore I think as the population increases, we need

to be building ever more capacity into our rapid public transport system and access to that, to meet demand. I think if we rely on the fact that we're gonna free up capacity, like I say, for autonomous vehicles on our roading network, we're probably kidding ourselves beyond more than an initial five to 10-year capacity improvement" (Interview 34).

"I think the most important thing is to put public transport in perspective. I don't think it's ever going to be a *dominant* force in transport. It's always going to be marginal. And the reason is quite simple: that you only rent something you don't use a lot, but which costs too much, and that's the only time you rent something. At the moment the operating cost of public transport is defined largely by the cost of labour, which is the driver. So in a taxi you're paying \$2.95 a kilometre but on a bus, I don't know what you're paying but, you know, that's subsidised anyway - but the bus driver is still the expensive bit. The point really being that if you're only paying 45 cents a kilometre for a second hand car, then so long as there's no non-utilisation cost, which is basically the cost of parking, then there's no particular reason to start suddenly using public transport. If you do have to pay for parking, which would be a brave thing to do but an entirely different issue, then it changes. Then I start to see the Uber thing starting to land differently" (Interview 50).

"Personally, the reason why I get up in the morning is because I dream of a future where cars are not a necessity for the poor, and frankly there are just a lot less cars on the road. And I think that if we can get there, that will have been one of the single biggest contributions that I could have made, and certainly that can be made in the personal transport space. It is just and maybe I am not seeing in front of my nose here, but it's just so obvious when you look to Australians and Kiwis, that something's got to change. We love our cars, we own cars, we can barely afford cars, we often sign leases that we can't afford just to get cars, we often need cars, especially in rural places and places with access to less accessibility, and the reason we are so invested in cars, is that cars are a great solution to a general problem. A train is a specific solution to a problem that is becoming less necessary; a bus is a slightly more flexible, but still the same version of that. Therefore, the question is not necessarily, how do we get people out of cars per-se, it is more about how do we make cars work as the most effective form of transport? And if you can do that, then if you take $\frac{9}{10}$ of them off the road, you would provide a much more lean environment to be able to adapt those cars to the changing environmental requirements" (Interview 28).