

Four Plausible Scenarios for Transport in New Zealand in 2048



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1) Introduction

Making decisions about the future is complex, not least because we can never be sure exactly what is going to happen. Historically, transport systems have experienced long periods of stability, punctuated by significant technological developments: the discovery of the wheel, the domestication of the horse, and the rapid succession of inventions in the late 1800s and early 1900s that led to the development of bicycles, trains, trams, subways, and then motor vehicles. We may be on the cusp of another disruptive round of change, and that leads to high levels of uncertainty about the future. We can choose to wait and see what happens, or we can plan to proactively shape our future as it emerges.

This document results from a project exploring the implications of changing transport systems. It has a particular focus on autonomous vehicles (AVs) and their implications for the wellbeing of older people and ageing populations. The project aims to facilitate proactive decision making about the future of transport in New Zealand. A summary document covering the wider content of the project to date is available (Fitt et al., 2018).

Transport needs and other features of society—including population demographics, urban form, human activities, technology developments, and social connections—have evolved together in complex ways over time (Docherty, Marsden, & Anable, 2017; Shove, Pantzar, & Watson, 2012). Going forwards, we can expect further changes. Some changes—like an ageing population—are broadly predictable because they are extensions of current trends. Others are much less certain. Even where we can have a reasonable degree of confidence about some changes, the complex interconnections between features and dynamics of social life make it impossible to predict our future world in accurate detail.

Even though we cannot predict the future, we can consider possibilities with a view to preparing for the likely, planning for the preferable, and avoiding the undesirable. In this document we talk about *plausible futures*. That is, things that could happen but about which we cannot be certain. In doing so, we hope to prompt discussion and therefore decision-making that is informed and proactive, even as it acknowledges the uncertainties of the future.

This document starts with some brief background on the development of AV technology, continues on to detail the development of our future scenarios, and finishes with four thought-provoking narratives, each telling a very different story about what New Zealand's transport system could look like in 2048.

Autonomous vehicle technology

Autonomous vehicles (AVs) are increasingly expected to be part of future transport systems. A wide range of vehicle manufacturers and technology companies is investing large sums of money in developing vehicles with commercial potential. Governments around the world have begun putting in place provisions for the use of such vehicles on public roads. Eventual widespread use of such vehicles is not certain, and there are challenges still to be overcome in domains including technology, but also public acceptance and domestic and international law.

We use ‘autonomous vehicles’ as something of a catch-all term. We acknowledge, however, that vehicles can be equipped with a range of different autonomous features, from assisted braking or steering, through to technologies that can perform all driving tasks without the involvement of a human driver. SAE International has developed a classification scheme to facilitate the development of a common terminology for vehicle automation (SAE International, 2016). We refer to this classification when we need to be specific about the kind of automation we are discussing. Box 1.1 provides a simplified version of the classification system. When we refer to ‘low automation’, we are referring to Levels 1 and 2 automation; ‘high automation’ (or to ‘highly autonomous vehicle’ or ‘HAV’) refers to Level 5 automation. We avoid the term ‘full automation’ (although this is used to describe Level 5 vehicles in the SAE International classification) because ‘full’ implies that future automation could not proceed beyond what is currently envisaged. We leave open the possibility that further levels of automation could be developed, perhaps including dynamic destination selection responsive to connections with other devices, such as refrigerators connected through the Internet Of Things (IOT).

A large number of vehicle tests and trials is currently underway (Bloomberg Philanthropies, 2017) and a number of producers are racing to develop HAVs for commercial availability.

Estimates of the timeframe over which we might see HAVs come to constitute a substantial proportion of the vehicle fleet vary widely. Some commentators suggest that a majority of vehicles in circulation could be highly autonomous as early as 2030; more conservative estimates consider widespread adoption more likely to have occurred by around 2060 (cf. Bansal, Kockelman, & Singh, 2016; Clark, Parkhurst, & Ricci, 2016; Haratsis, 2016; Kanter, 2015; Litman, 2017). Clark et al. (2016) and Litman (2017) provide more complete reviews of timeframe estimates.

Later, we present some scenarios exploring possible transport systems in the year 2048. We chose 2048 for a number of reasons, including that some of the stakeholders in our project (with whom we discussed the scenarios) advised it was not so far in the future as to be difficult to relate to or to imagine. Also, 30 years from now people who are currently middle aged (including many of New Zealand’s decision makers) will be in older age brackets; this age group is the one with the most strongly entrenched driving habit. Some of our scenarios include fleets comprised almost entirely of HAVs. We acknowledge that 2048 provides an ambitious timeframe for technology adoption but argue that pushing boundaries a little is appropriate in a document that is intended to prompt thought and discussion.

Box 1.1: Levels of automation

Level 0 – vehicles with no automation

Level 1 – vehicles with either assisted steering or assisted acceleration and deceleration

Level 2 – vehicles with both assisted steering and assisted acceleration and deceleration

Level 3 – vehicles that can drive themselves in some circumstances but require a human driver to be available to retake control if necessary

Level 4 – vehicles that can drive themselves in some circumstances without a human driver

Level 5 – vehicles that can drive themselves in all situations that a human driver could be expected to manage (HAVs)

Adapted from: (SAE International, 2016)

Our scenarios focus on autonomous passenger vehicles. We acknowledge several related technologies that are likely to influence future transport systems but which, in the interests of brevity, we exclude from our primary focus. For example, we do not devote significant attention to freight vehicles, to vehicle connectivity, or to non-land based vehicles such as drones. Freight operations may provide early opportunities for routine use of AVs, and such use could have widespread social implications including for the future of work, for consumption behaviours, and for traffic management.

Box 1.2: A brief history of vehicle automation

Vehicles that can drive themselves have been imagined at least since Leonardo da Vinci designed a self-propelled cart with 'programmable' steering around the turn of the 16th century (da-Vinci-Inventions.com, 2008; Lorenzi, 2004). Subsequent developments, including vehicle motorisation and the use of cameras and radar, improved the performance of self-driving vehicles, but by the turn of the 21st century these were still far from practical transport solutions (Anderson et al., 2014). Then, in 2004, the US Defence Advanced Research Projects Agency (DARPA) introduced the first of what was to be a series of high stakes competitions with the ultimate aim of developing autonomous vehicles that would be able to function successfully in hazardous military situations (DARPA, 2014). The first challenge was to complete a 142 mile driving course through the Mojave Desert; the highest placed competitor completed only 7.5 miles of the course (DARPA, 2014). This and subsequent challenges did, however, result in an increased impetus to solve some of the problems of autonomous driving, and in collaborations and co-operations that brought together experts with a range of complementary skills (Anderson et al., 2014; DARPA, 2014). By the third, and final, DARPA challenge in 2007, six teams had developed vehicles that were able to complete a 60 mile urban course, avoiding other vehicles and obeying traffic regulations (DARPA, 2014). That success heralded increasingly concerted attempts to produce an autonomous vehicle that could be used in everyday civilian transport.

Connected vehicles are equipped with technology that allows wireless data transfer between vehicles (known as V2V communication), between vehicles and infrastructure (V2I communication), or between a vehicle and any entity that may affect it (vehicle to everything, or V2X, communication). Such communications could assist in vehicle safety, vehicle efficiency, and automatic vehicle routing; all of which could have socially significant impacts. Aerial transport technologies (targeted at the movement of both freight and passengers) are also being developed and tested around the world. Increases in aerial transport could radically transform urban environments and early consideration of its potential impacts would be prudent. While we acknowledge the significance of all of these potential changes to transport systems, our scenarios focus primarily on land-based, passenger vehicle automation.

We assume that most future vehicles will be electrically powered. France, the UK, Norway, and China, and a number of vehicle manufacturers, have established targets or strategies to transition away from internal combustion only vehicles (Petroff, 2017; The Economist, 2017; Vaughan, 2017). Stakeholders in our research have argued that a continued dominance of combustion driven vehicles is unlikely and Wolmar (2018) suggests

electrification is a precondition for automation. We also note that a move to electrically powered vehicles will facilitate progress towards vehicle automation because it is technologically easier to produce an electric autonomous vehicle than one powered by an internal combustion engine.

2) Developing future transport scenarios

Scenarios can help us to think about the future from different perspectives. A common scenario development technique is to use key (global and local) drivers to inform the construction of what Shergold, Lyons, and Hubers (2015) term a 'double uncertainty matrix' (see also Banister & Hickman, 2013). The double uncertainty matrix consists of two axes portraying the extents of uncertainty in two dimensions. Placing the axes in a cross formation leaves four possibility quadrants with different characteristics. The identification of different sets of characteristics allows the development of a scenario for each quadrant. This technique has been used by the New Zealand Ministry of Transport. For example, in the Future Demand exercise, Lyons et al. (2014) considered the potential implications of two possible social dynamics: changing energy costs relative to incomes and living costs, and differing social preferences for virtual or face-to-face connections. The resulting double uncertainty matrix and scenario outlines are shown in Figure 2.1. In a more recent exercise, the Ministry of Transport has modelled changes in trips, mode share, and distances travelled for four scenarios based around accessibility preference (physical compared to virtual) and uptake of autonomous vehicle technologies (Ministry of Transport, 2017). The report also models the health benefits (in terms of active travel) from modal shift, but does not consider wider health and wellbeing implications.

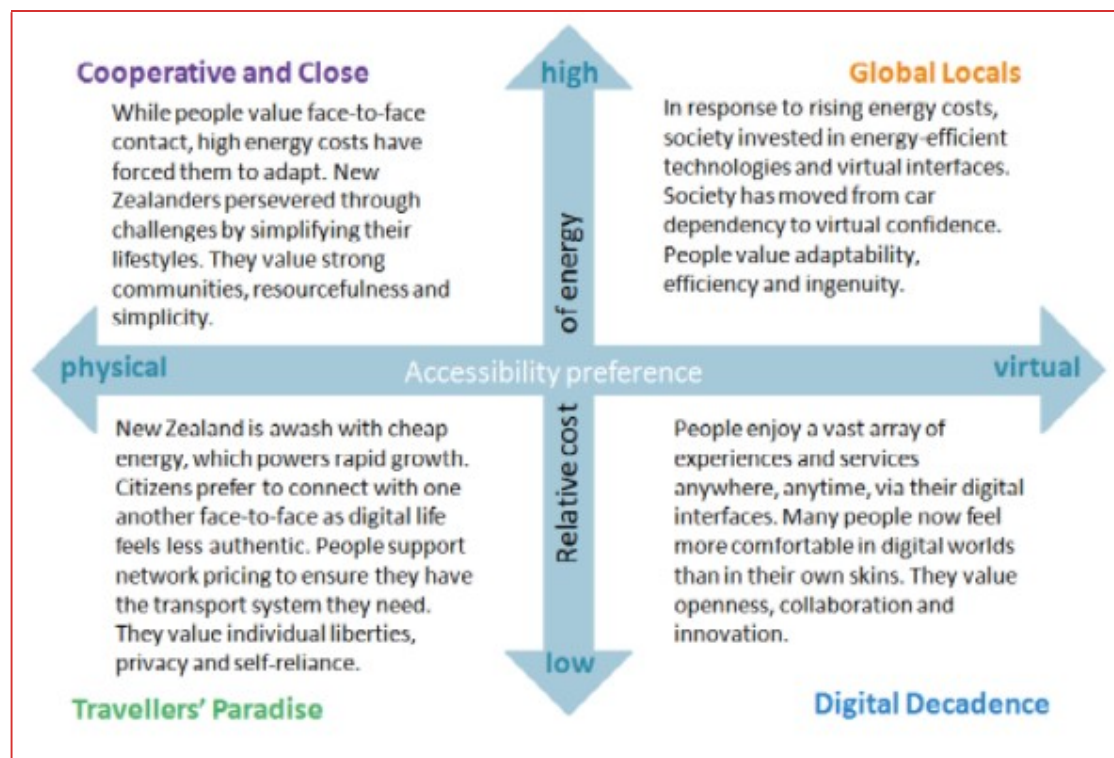


Figure 2.1: Ministry of Transport Future Demand scenarios.
 Source: The Ministry of Transport and licensed by the Ministry of Transport for re-use under the Creative Commons Attribution 4.0 International (BY) Licence. (Lyons et al., 2014)

Key drivers

The definition of the axes for a double uncertainty matrix requires the identification of key drivers. In this project we considered the Political, Economic, Social, Technological, Legal, and Environmental (PESTLE) drivers of possible changes to our transport systems. In conducting and presenting this analysis we acknowledge that the world is enormously complex and it is well beyond the current scope to catalogue all possible drivers of future transport systems. However, PESTLE analysis provides a framework for analysing a complex range of factors that may influence future systems (see Liggett, Frame, Gilbert, and Morgan (2017) and Sridhar et al. (2016) for further examples of 'PESTLE' analyses). Here we highlight those drivers we think are most critical to our focus on future transport systems as well as those most commonly drawn out in the literature reviewed. We also acknowledge that drivers are interdependent. While they are presented as essentially discrete categories of influence below, we note that, for example, political, economic, legal, and social dynamics are intricately entwined and interdependent.

Political

One of the key current drivers of autonomous vehicle technology is interest from a range of powerful actors, including national and local governments. Governmental support for autonomous vehicle trials and adoption is evident in a range of jurisdictions and is responsive to a range of different subsidiary policy drivers, many of them economic. For example, the current US administration is pursuing a light regulatory approach prioritising national economic competitiveness and rapid innovation (though critics contend that voluntary guidelines may not be adequate to protect public safety) (NHTSA, 2017; Zanona, 2017). At the same time, Singapore couples promotion of an innovative technology sector with a focus on moving towards a 'car-lite environment' and was first in the world to launch a public trial of autonomous taxis (McSpadden, 2016; Meng, 2017). The European Union is pursuing strategies responding to the market potential of automated vehicles (European Commission, 2016). Similarly, the UK government is targeting economic growth from a prioritisation of autonomous vehicle technology, and may be at an advantage compared to many of its European competitors having not ratified the 1968 Vienna Convention on Road Traffic, which essentially requires a vehicle to have a human driver (Tovey, 2016).¹ The UK has set up a Future Cities Catapult initiative to act as a bridge between industry and academia, and has provided research funding to explore AV technologies (Moss, 2015). Not all governments are optimistic about the potential of autonomous vehicles and India's road transport and highways minister was recently reported as saying "We won't allow driverless cars in India. I am very clear on this" (Das Gupta, 2017). Increasingly the expectation that vehicle automation will happen regardless of any nation's domestic strategy seems likely to influence supportive policy directions.

Potential risks related to terrorism and cyber-crime may, however, have a dampening effect on political enthusiasm for vehicle automation; these risks are covered in more detail in the Social and Technological driver sections. Major high risk, low probability events (such as large scale war or devastating pandemics) are beyond the scope of our work, but any given consideration could be incorporated into an extension of this project.

¹ The UK did, however, ratify the earlier Geneva Convention and is still bound by some (looser) restrictions on vehicle drivers and the Vienna Convention was updated in 2014 to allow some concessions to automation technology (Bradshaw-Martin & Easton, 2014).

Economic

Clearly, many of the political drivers for an adoption of autonomous vehicles are economically motivated. Indeed the European Commission expects that the market potential of autonomous vehicles and associated service industries could reach dozens of billions of Euros annually (European Commission, 2016). The commercial potential is also providing strong encouragement to technology companies, the automobile industry, and associated entities (Docherty et al., 2017). The large investments being made in this space by companies including Waymo (formerly the Google self-driving car project), Tesla, Uber, Ford, GM, Volkswagen, and Volvo indicate potential gains. Economic gains are likely to continue to drive powerful corporations towards automation technology.

The economic drivers of autonomous vehicle consumption are much less clear than those guiding technology development. It is very commonly argued that, in an autonomous future, consumers will be less likely to purchase a vehicle, instead accessing vehicles through car sharing services. Car sharing has been increasing in popularity over recent decades and is estimated to have between one and two million users worldwide (Le Vine, Lee-Gosselin, Sivakumar, & Polak, 2014; Shaheen & Cohen, 2013). This has happened in the context of shifts in the economic models that allow access to goods and services (Belk, 2014; Botsman & Rogers, 2010; Sundararajan, 2016). Facilitated by Web 2.0 technologies, increased computing power, and online systems, services like TradeMe, Airbnb, Uber, Cityhop, and SHAREaCAMPER have emerged (Botsman & Rogers, 2010). New economic models connect demand and supply across large populations, permit distributed real-time transactions, and allow strangers to engage in trust-based interactions. Some argue that new economic models are already fundamentally changing the shape of economic transactions and will continue to do so, to a greater and greater extent, as they become more sophisticated and more prevalent (Botsman & Rogers, 2010; Sundararajan, 2016).

Increases in car sharing may be driven by cost and convenience. The per-trip costs of owning a vehicle are high, especially if the costs of at-home parking (including garaging), cleaning, and maintenance are included (Le Vine et al., 2014; Litman, 2017). Car share schemes (whether commercial, peer-to-peer, or hybrid) can spread overheads amongst users thereby considerably reducing per-trip costs. Vehicles that incorporate sophisticated automation technology are likely (at least initially) to have higher purchase and maintenance costs, thus increasing the benefits of sharing schemes. In addition, current users of car sharing schemes have to travel to the—variably convenient—parked location of a shared vehicle (Dowling & Kent, 2015). In contrast, autonomous vehicles could travel to a requested pick-up point, thus substantially increasing the convenience of vehicle sharing. Together, the reduced cost and increased convenience of autonomous vehicle sharing, alongside broader shifts towards new economic models, could lead to a transformation in vehicle and travel consumption. This possible transformation underlies many of the claims commonly made about the potential benefits of autonomous vehicles (such as their benefits for older people and for the environment) and is likely to be a key influence on dynamics associated with the wellbeing of older adults.

Our scenarios take account of possible changes to economic models of car use. Though feasible, other major economic disruptions are beyond our scope but could be incorporated into future scenarios.

Social

Social drivers of future transport systems can include changes in societal views, preferences, and needs, and changes in the demographic make-up of society. As generations age, preferences for travel, amongst other things are likely to change (Curl et al., 2018). For example, much attention is currently being paid to the reduced level of car ownership among younger people (e.g. Chatterjee et al., 2018) – who will be the older generation of the future. It is important to consider the implications of demographic shifts.

Preferences for shared travel or independent travel will evolve alongside models of vehicle ownership and use. Recent research indicates a preference for sharing services that do not require social interaction between users (International Transport Forum, 2017a, 2017b). Economic models of collaboration mediated through the internet (such as TradeMe, Airbnb, and Uber) are growing in popularity, but increases in online collaboration may not translate into increasing preferences for face-to-face interactions. This could drive futures in which any ride sharing services that exist consist of vehicles designed for minimal social interaction between users. Wider preferences for face-to-face compared to virtual connection are considered in more detail in (Lyons et al., 2014).

Other (largely non-economic) social preferences could further influence dynamics around car use and ownership. Cars and driving are widely regarded as carriers of strong social meanings, including adulthood, status, freedom, independence, masculinity, professional accomplishment, and social group membership (see for example Bergstad et al., 2011; Gatersleben, 2011; Griskevicius, Tybur, & Van den Bergh, 2010; Sachs, 1992; Steg, 2005; Stokes & Hallett, 1992; Urry, 2000; Watson, 1996). Although individuals may sometimes behave as rational economic actors (making decisions based on cost and convenience) they are also influenced by social meanings and social norms. Meanings and norms can change, and advocates of the concept of 'peak car' suggest that car ownership and driving are losing some of their social importance. However, these social dynamics are still strong drivers of transport practices. These drivers currently provide pressure towards personal car ownership and the acquisition of driving skills (Fitt, 2016).

Societal concerns around data sharing practices could also help shape future transport systems. Some of the stakeholders with whom we have discussed our scenarios have argued that data privacy, storage, ownership, and use concerns are more likely than concerns about vehicle operation to impede widespread uptake of AV technology. This might be especially so for older adults. EU autonomous vehicle policy has a particular focus on privacy issues and specifies that data uses must comply with strict data protection laws (European Commission, 2016). Societies' attitudes towards privacy and sharing will inform commercial operations, government policy, legislation, and the technical specifications of vehicles and their data uses.

Beyond privacy and data sharing, concerns around terrorism and vehicle hacking may become strong social currents. Technology developers will need to earn consumer trust if autonomous vehicles are to be widely adopted, especially if high levels of vehicle connectivity make entire vehicle systems vulnerable. Society may be less willing to accept these new risks, than to accept the established and familiar risks associated with human error (McKinney, 2017).

Technological

Current debates around AV adoption feature concerns about the levels of automation that will be publicly available at different points in time. Some manufacturers (including Audi, Tesla, BMW, and

GM) currently appear to expect to move sequentially through the levels of vehicle automation, incrementally increasing their autonomous capabilities. Other manufacturers (including Volvo, Ford, Waymo, and Mercedes) have expressed concerns about levels of automation (and specifically Level 3 automation) that require a human driver to retake control of a vehicle if required (Auto2x, 2017; Ayre, 2017; Gain, 2017). At the time of writing, there is a lack of consensus around preferred trajectories through levels of automation, however, consensus does appear to be increasingly leaning towards an avoidance of Level 3 automation. It is also worth noting a considerable degree of scepticism amongst stakeholders that autonomous vehicles will be able to deal with all road conditions (including extreme weather and rural roads of variable standards) in the near to medium term future. Most stakeholders argue that highly autonomous vehicles will initially only operate in a narrow range of circumstances. This means that the vehicle fleet is highly likely to remain mixed even in high automation scenarios.

Legal

There are numerous legal issues associated with adoption of AVs; revisions to domestic and international legislation will be prerequisites for widespread uptake.

Complex legal issues associated with AVs include how to determine and apportion accident liability between an autonomous vehicle user, vehicle supplier, software manufacturer, and software installer; how to assess liability and damages when an autonomous vehicle is in a collision with a non-autonomous vehicle (or indeed when two vehicles with different levels of autonomy or different software configurations collide); and whether changes to (or potentially abolition of) driver licencing laws are required. These issues may have different implications in different legal jurisdictions, for instance New Zealand's Accident Compensation Corporation (ACC) may simplify liability issues compared particularly to the more litigious approach of the United States (Ministry of Transport, 2009). Issues around insurance and liability are discussed in more detail in Fletcher, Fitt, Baldwin, Hadfield, and Curl (2018). It is unlikely that widespread adoption of autonomous vehicles will be possible in New Zealand without widespread adoption elsewhere (largely because of the size of the New Zealand vehicle market and its appeal to international vehicle producers). This means that legislation enacted in other jurisdictions will have a key impact on future transport systems in New Zealand.

Laws restrict the activities that can be undertaken, but are relatively responsive to underlying social, political, economic, and technological conditions. There are many examples of laws being updated in response to changing circumstances; recent New Zealand examples include the Harmful Digital Communications Act 2015, the Copyright (Infringing File Sharing) Amendment Act 2011, and even changes to maximum speed limits on some roads introduced in 2017 (NZ Transport Agency, 2017). Internationally, there are also examples of laws already being introduced or adjusted in response to autonomous vehicle technology. For example, the 1968 Vienna Convention on Road Traffic was updated in 2014 to allow some concessions to automation technology (Bradshaw-Martin & Easton, 2014). Germany has passed these changes into domestic law (Gesley, 2016), and in the United States, the National Conference of State Legislatures has developed the Autonomous Vehicles Legislative Database (NCSL, 2017) to help keep track of legislative changes across different US jurisdictions. It seems likely, then, that legal requirements may slow any adoption of autonomous vehicles (perhaps considerably in the case of some of the particularly challenging ethical issues,

which are discussed in more detail in (Fletcher et al., 2018)) but that laws will respond to, rather than fundamentally drive, developments in future transport systems.

Environmental

Moves towards autonomous electric vehicles could have substantial environmental benefits. Electric vehicles have lower emissions than internal combustion alternatives, and AVs operate more efficiently than human driven vehicles. The potential environmental benefits of these moves are drivers of technology adoption, for example, the European Union explicitly links issues of smart mobility to climate policy through its climate emissions reduction policy (European Union, n/d). Environmental motives may also drive moves towards a sharing economy from the perspectives both of consumers and of public sector agencies developing facilitating policy or legislation (Botsman & Rogers, 2010). Expectations of vehicle sharing in turn underlie many of the presumed environmental (and social) benefits of AV technologies. It is possible that an increasing visibility of the effects of climate change could lead to increasing scrutiny of the environmental credentials of different transport system configurations. Currently, however, the other drivers discussed above appear to be having more influence on planning and decision making with regard to AV technologies.

Future transport scenarios

We reviewed the drivers detailed above for their significance for transport systems, and especially for their significance for an ageing population. We found two dynamics to be of particular interest.

The **level of automation** that might be prevalent in future transport systems is interesting for two reasons. First, there are competing factors driving alternatively towards high or low automation. Figure 2.3 provides a simplified illustration of the directions in which some of the key factors discussed above may drive transport systems. Second, research team brainstorming exercises suggested that the levels of automation in transport systems might have particular relevance for urban form and older people. For example, for older adults who cannot drive, the difference between Level 3 automation (which automates the driving task in some circumstances but still requires a human driver) and Level 5 automation might be the difference between transport exclusion and transport inclusion.

New economic models that might influence how cars are accessed and used are also particularly interesting in the context of future transport systems. There is considerable evidence that economic systems have been changing in recent years with the emergence of new kinds of transactions with a growing influence on interactions between people, and between people and assets (e.g. Paypal, Bitcoin). We have also seen the development, proliferation, and popularisation of different ways of accessing travel, including schemes such as commercial car-share (e.g. Zipcar and Cityhop), peer to peer vehicle-sharing (e.g. Yourdrive and SHAREaCamper), ride-hailing (e.g. Uber and Lyft), and ride-sharing (e.g. local carpooling arrangements). The mobility schemes of some automotive companies—not entirely successful to date, but still evolving—, such as Ford’s failed Credit Link programme in which a self-organised group of people could share a car lease, is an example of this new mobility trend. There are also experiments with on-demand, door-to-door public transport, and other schemes such as Mobility as a Service (MaaS) that facilitate multi-modal travel (for example, using a combination of public transport and bike share). It is far from certain whether vehicle ownership will prevail as a dominant way of accessing transport into the future. New economic

models for transport access could have profound implications for how cities work and for the mobility of older people. In addition, these changes could play out quite differently depending on different levels of automation. For example, the costs of providing on-demand, door-to-door public transport could reduce substantially if automation negated the need to pay driver wages.

The identification of two dynamics that are of particular relevance to future transport systems and older people allows the development of a double uncertainty matrix.

The dimensions of uncertainty selected are:

1. The levels of automation included in future transport systems
2. The economic models on which future transport systems are based

These dimensions of uncertainty are shown as axes in [Figure 2.2](#).

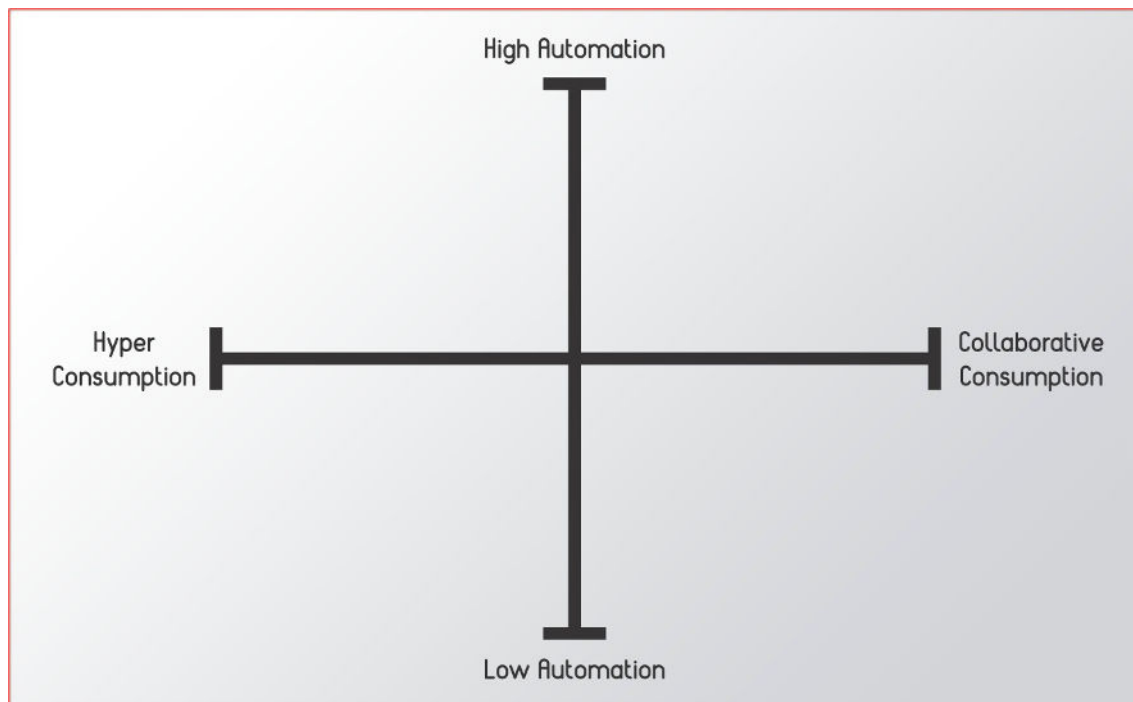


Figure 2.2: Scenario axes

For ease of reference to traditional and new economic models we follow Botsman and Rogers (2010) in using the terms 'hyper consumption' and 'collaborative consumption'. Botsman and Rogers (2010) describe hyper consumption as being defined by individual ownership and facilitated by advertising and easy availability of credit. In contrast, collaborative consumption is defined by shared access and is facilitated by reputation and community building. Other definitions have been put forward for new economic models and there is currently no consensus on which is most appropriate to future transport systems (Sundararajan, 2016). In-depth definitions often share features like the use of internet technology, the optimisation of underused assets, and the development of trust mechanisms (Sundararajan, 2016). Differences commonly feature the extent to which services are commercially driven, the involvement of corporations and/or peer-to-peer interaction, and differences in geographical scales (Sundararajan, 2016). Differences in definitions are accompanied by a diversifying portfolio of terms including the 'collaborative economy', the 'sharing economy', 'crowd-based capitalism', 'gig economy', 'peer economy', 'renting economy', and 'on-demand economy' (Sundararajan, 2016).

Figure 2.3 demonstrates how the drivers outlined above may influence outcomes with regard to these two axes of uncertainty. Note that the number of arrows pointing in each direction is not necessarily an indication of probability as some drivers will be stronger than others and the relative strength (and direction) of drivers could change over time. This figure is simply an illustration of current considerations informing the choice of axes.

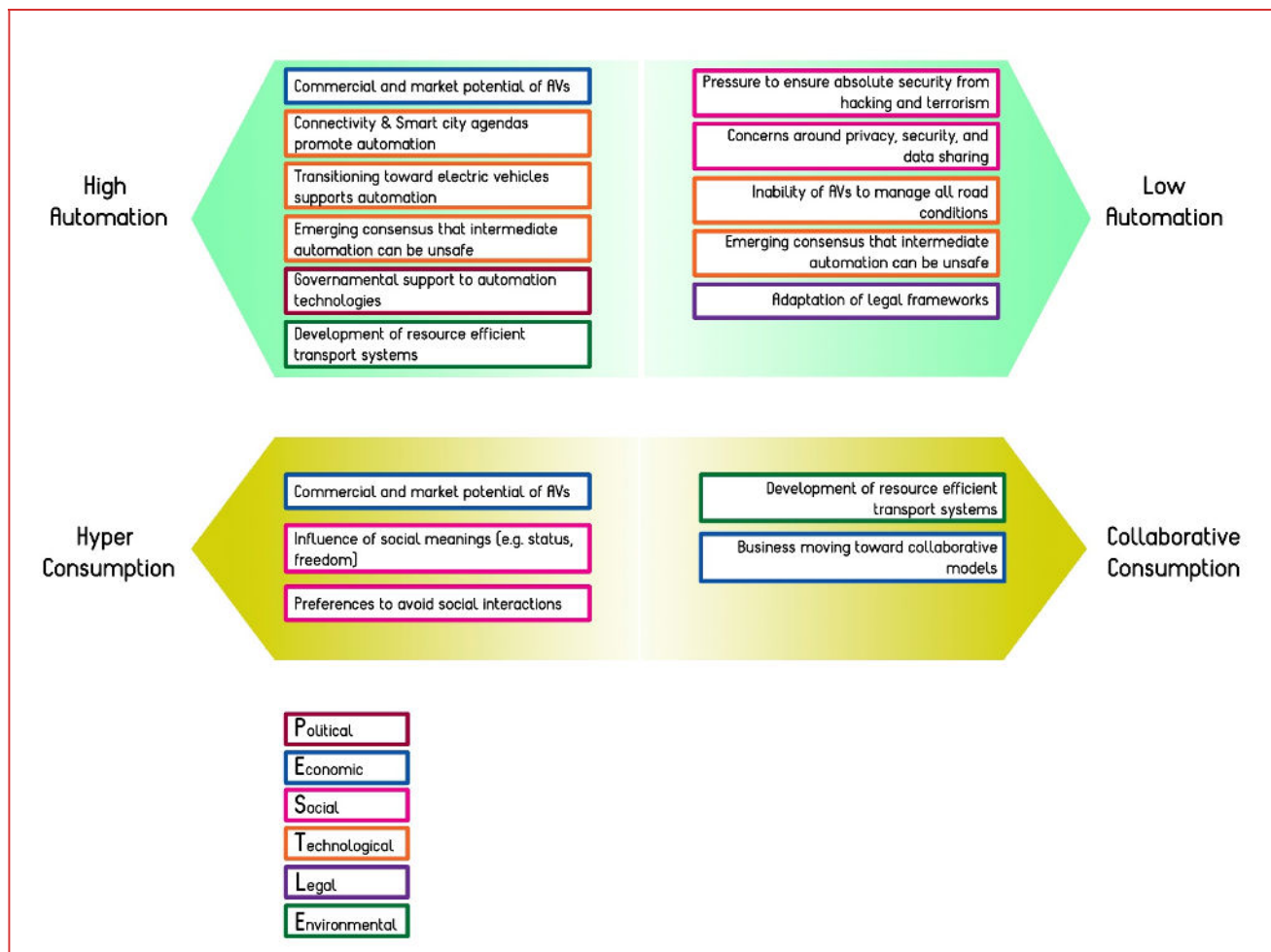


Figure 2.3: PESTLE drivers and likely directions of influence

Scenario outlines

We used workshops, discussion, and stakeholder consultation to devise four scenarios that inhabit the four possibility quadrants between the two uncertainty axes as shown in Figure 2.4.

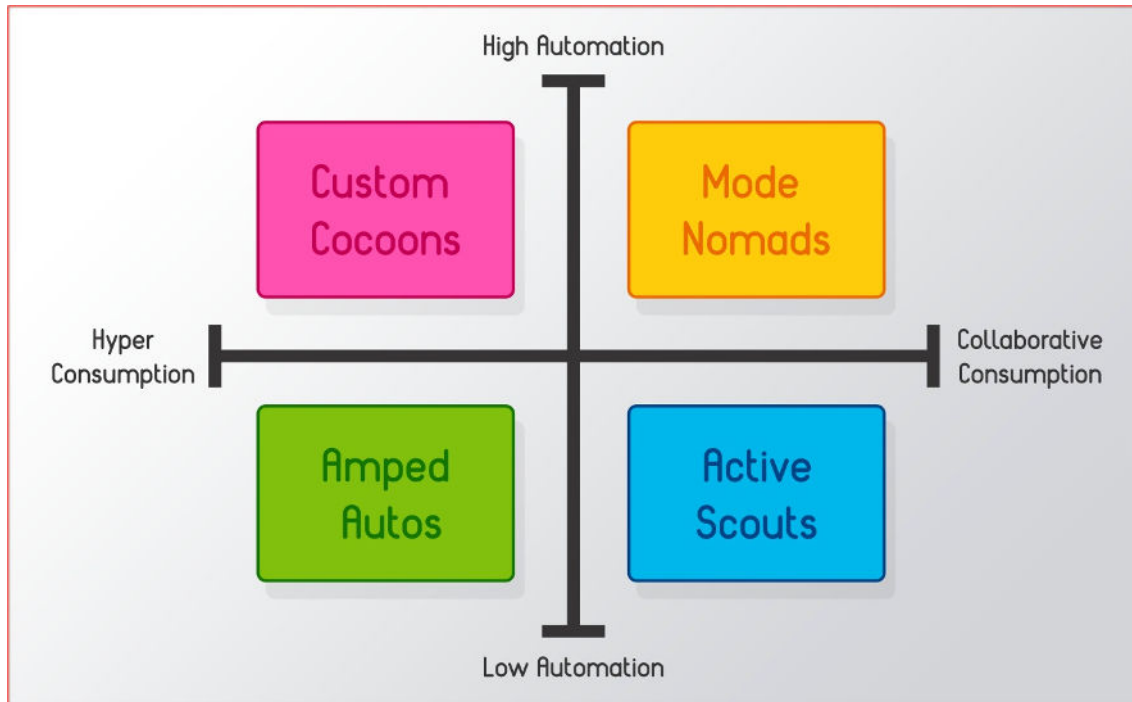


Figure 2.4: Possible NZ transport systems (2048)

Narratives describing each scenario in detail are provided below. Note that these scenarios are not an attempt to predict what will happen or to indicate which possibilities might be preferable; they are designed to be plausible possibilities that will trigger discussion and proactive responses and that can facilitate a consideration of some of the possible implications of different changes to transport systems.

In the New Zealand of Custom Cocoons, almost everyone owns their own driverless car.

Now that cars drive themselves more safely than humans ever could, most people have given up driving and have enthusiastically embraced the freedom and safety that autonomous vehicles provide. Most people have their own individualized cocoon available at a moment's notice. Just say the word or use the app and your virtual PA will summon your cocoon to come and find you, wherever you are.

Some people choose cheap and cheerful cocoons, others choose the heights of luxury; it's entirely up to you...but remember that you can't just buy your cocoon and forget about it. You'll need to pay for software updates (which are more expensive for luxury models) and insurance (which is actually cheaper for high quality cocoons). It's a tricky balancing act, but if your cocoon isn't up to date, smart infrastructure embedded in the road network will immobilise it...and then you won't be going anywhere fast.

Getting around

Most of us go pretty much everywhere in our cocoons, it's just so easy and convenient. There's not much public transport anymore and virtually nobody used it anyway, especially once children started to get their own cocoons. Some people do still walk and cycle for leisure and exercise, and biking is almost totally safe now that vehicles are programmed to avoid collisions. Most people agree that increased safety is a good thing (though, paradoxically, public sensitivity to risk has increased as actual road safety has improved).

In the early days of cocoons pedestrians quickly realised that they didn't have to look for crossings any more, or even really pay attention when crossing the road. They just walked out, and expected the cocoons to stop...which they did. That got pretty annoying pretty quickly for the people in the cocoons and it didn't take long for walking or cycling on or near roads to be generally considered antisocial, earning it the nickname 'punking'. Now you get an automatic fine if one of your mobile devices is detected on a road but not in a vehicle. This has pretty much stopped punking, but it does mean that if you want to cross a road, you have to find a designated crossing point. Most people find crossings too far apart to make actually getting anywhere on foot or by bike practical; it's cocoons all the way.



Cities and towns

Our cities and towns are busy places, full of roads packed with cocoons whizzing people around. 'Zombie cars' even drive themselves in endless holding patterns to avoid parking charges. Cities have expanded outwards over recent years as more and more space is taken up by roads and more and more people move outwards in an ever-expanding search for peace and quiet. If you look at our city at night, it's a strangely beautiful mass of ever-moving lights.

Health and wellbeing

Most of us agree that not having the stress of driving anymore is a good thing. On the other hand, now we go pretty much everywhere in cocoons, we don't get much exercise. Some people are starting to take fitness pills to compensate for the lack of exercise, but we're really not sure what the long term effects of those are and a lot of people are quite sceptical about the benefits.

The biggest wellbeing challenges are probably for those people who can't afford their own cocoon. With essential services a long way apart, and communities cut in two by roads you can't cross without getting fined, it can be really difficult to manage without a cocoon. The government does provide some taxi subsidies for those without their own cocoon, but those barely cover the costs of essential travel. It's really much better to have your own cocoon.

Government policy

Our government tries not to interfere too much in the free operation of markets. There has been some concern recently about people trying to hack cocoons for disruptive or nefarious purposes and some commentators have suggested legislation on software standards; it seems more likely that our government will prefer to encourage software developers to compete for consumer trust by producing more and more hackproof systems.

The downside of encouraging software developers to compete is that vehicles all operate on different systems, unable to take advantage of some of the connectivity that is possible in theory. For example, our cocoons can't drive close together in high speed platoons that could reduce traffic congestion and increase fuel efficiency. We're pretty lucky though that (as long as we own an up-to-date cocoon) we can go wherever and whenever we want.

Mode nomads whizz around this New Zealand in driverless vehicles, often switching to walking and cycling in dense urban areas.

To understand our New Zealand, you have to understand caps, capzones, and KiwiNet. ‘Caps’ are automated travel capsules; they come in a variety of sizes and configurations and they can travel on any part of the transport network. The transport network is divided into capzones and streets. ‘Capzones’ are where caps work best; these are high speed corridors where there is nothing to impede fast travel. Globally, the first capzones replaced motorways and freeways, and then increasingly they also replaced other main thoroughfares. In capzones, caps platoon automatically, taking advantage of the efficiency gains of travelling in closely packed convoys. Caps join and leave the capzones in carefully (but automatically) choreographed merging patterns to minimise efficiency losses.

Streets are very different to capzones; these are shared spaces where caps coexist with cyclists, pedestrians, and playing children. Historic distinctions between vehicle lanes and footpaths are obsolete and space is openly shared. Children learn about the concept of jaywalking in history lessons at school; the idea of organised pedestrian crossings usually prompts gales of laughter. In streets, caps travel very slowly, weaving their way between other street users and giving way often. Most people only use caps on streets if they’re not in a hurry, if they can’t walk or cycle, or if the weather is truly atrocious.

KiwiNet is the brain of our transport network, it’s managed through blockchain technology and it keeps the whole system running smoothly. The public face of KiwiNet is a single app that can be used to summon a cap, find a shared bike, or work out the best route to walk, skate, or hoverblade to your destination.

Most of the caps (and shared bikes) managed by KiwiNet are actually owned by non-profits or social enterprises and KiwiNet sets ride prices dynamically according to parameters like distance, congestion management, and the sustainability of vehicle provision and maintenance. Citizens have KiwiNet accounts from which all their travel costs (including cap or bicycle use) are automatically deducted.

Getting around

It doesn’t take a genius to work out how we get around. If we’re going any distance, we use the capzones; for shorter journeys most of us prefer active travel because it’s quicker and much cheaper (especially in peak travel hours). Most people give KiwiNet auto-access

to their calendars and it plans their travel according to their preferences and (if needed) it can provide livestream instructions while they are travelling.

You could probably count on one hand the number of times in a year that a pedestrian or cyclist gets hit by a cap. Usually when that happens, it’s because drunk students have been actively trying to trick a cap into hitting them. When they do get hit, it’s usually just a couple of bruises and a lot of ‘likes’ on their social media livestream.

Cities and towns

Our streets are bustling with life. Alongside pedestrians and cyclists, are also pop-up markets, neighbourhood deckchair movie nights, and kids’ fun days. When an event is on, caps will just be directed another way, or will pick their way through at a snail’s pace. Rural townships are more connected than ever to cities as KiwiNet uses capzones to create high speed corridors to connect the outlying towns to the bigger cities.

At night, capzones and streets are used by caps for goods deliveries, but caps still give way to other users on streets. Night time crime levels have dropped as the constantly moving vehicles give the impression of always being watched.

Health and wellbeing

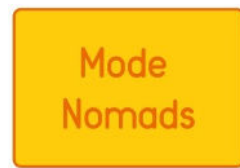
One of our government’s most strongly held beliefs is that access to facilities is a social right. As all travel costs are managed by KiwiNet, it’s pretty straightforward for the government to provide credit for people with low incomes or with impairments that restrict how they can travel.

Beneficiaries have complete control over how they spend the credit but, of course, there are support and planning services for those who struggle to manage their travel budget.

Government policy

Although there are still some cars around that require human drivers, their use is considered dangerous, is illegal in most situations, and is primarily restricted to historical events and specifically-zoned recreational opportunities.

Regulation requires all caps to operate through KiwiNet and, beyond the public face of its app, KiwiNet manages traffic flows in the capzones, ensures hardware and software quality and standardisation for caps, calculates road use levies, and performs all the essential functions of a transport system. Government blockchain specialists have ultimate oversight of KiwiNet.



In this New Zealand, citizens are Active Scouts, seeking out the best ways to travel and using a variety of different options.

A few years ago, engineers assumed that by now we would all be zipping around in driverless cars. What they didn't count on was the backlash to perceived abuses of consumer privacy and the strong public reaction to early fatalities. Global consumer mistrust meant people weren't willing to accept vehicles they felt were constantly watching them and where they couldn't retake control...and after briefly playing with cars where you could hover your hands over the steering wheel and retake control if necessary, most people decided that paying attention to not-driving was a lot harder than just driving the car.

Most people don't own cars anymore though; it's just too expensive when you take things like tax and parking costs into account. We use car share schemes to hire a vehicle when we need one. There are several really good travel apps that facilitate car sharing, but more and more people are moving to the most popular app, Swoosh.

Swoosh's strategy was to dominate the market for corporate vehicle fleets. Once your employer uses Swoosh you have to get a Swoosh profile, and now lots of us have employment contracts that require us to maintain our sharing reputation on Swoosh. Once you're doing that for work anyway, you might as well use the discount benefits of a strong reputation for your personal trips as well (although sometimes using one service for everything does feel a bit big-brotherish).

These days, it's pretty common to actively pick the best way to make each trip. For routine trips we all have our preferred options, but we often change what we do because of the weather, or because of side-trips, or even because we just feel like doing something different. Swoosh is always on hand to help us make choices between the available options and to make paying for them simple.

Most people pay for all their travel through Swoosh. You can get unlimited public transport with an 'UP' pass, but each time you use a car, money is deducted from your account to pay per-trip taxes. That makes car travel seem a lot more expensive than public transport so lots of people only drive when they've got a big load or are going out of the way.

Public transport is really popular. The Bus Rapid Transit (BRT) systems in all the cities are excellent and high levels of investment and use are allowing for more and more routes



and more and more frequent services to be added. We also walk and bike a lot and doing so has got much safer since the apps allowed users of all travel modes to downgrade a driver's reputation. Drivers are much more courteous now they know bad behaviour damages reputation. Bike share schemes are also popular, and they connect well with all the public transport facilities so that makes it super-easy to get around without needing to get a car.

Cities and towns

Our cities are densely packed but don't have the levels of congestion that they used to before the BRT investments. They also have lots of green space now that most of the parking has been removed to discourage car use and make our cities nicer places to be. Most of us like to live fairly close to the places we go often and it's pretty rare for us to travel all the way across town. That said, residential areas near to BRT routes are popular because they do provide that extra flexibility in terms of getting around.

Health and wellbeing

Our cities are pretty nice places to be, they're dense, but they have plenty of green spaces and most of us can access all the things we need locally. We get plenty of exercise and wellbeing in urban areas is at an all-time high.

People with special mobility needs or low incomes can access free UP passes, which give them pretty good mobility. Some people argue that they should get free access to cars too, but given the government's attempts to deter car use that seems unlikely to happen. Admittedly, relying on public transport does place some restrictions on where you can live, but these are reducing as BRT and other transit networks grow.

Government policy

Our government tries to take a responsible approach to managing the costs that vehicles impose on other people and on the environment. Vehicle taxes and parking charges are high, and construction of parking is restricted.

We have some complex regulations that encourage businesses to collaborate but discourage collusion. This can cause headaches for those negotiating trade deals but we are also, in some respects, considered a world leader that others aspire to follow.

At the moment, there is some concern about market domination by Swoosh and whether we need legislation to prevent a monopoly and subsequent rises in travel prices. We're not sure how this one's going to play out, but pretty much everyone has an opinion.

In the New Zealand of Amped Autos, people love to drive; so much so that motor-racing is the national sport.

If you've ever experienced the thrill of taking racing turns through quiet mountain roads then you can probably *feel* what drives our love of cars and driving. Yes, carmakers flirted with driverless cars, and they managed to make them practical...but it was only after all that effort that they realised that our love of cars isn't just about practicality. We love cars because they *feel* good, and no amount of effort can make a passive passenger feel like a driver.

It was a few decades ago now that there were moves to try to get us sharing cars more and owning them less, but the scale of this shift and the time required to achieve it fully were too overwhelming for governments that institutionally focus on short-termism and the next election cycle. Moreover, when you own a car you can make it your own (that's why they call it '**ownership**'); you get to know its little quirks and idiosyncrasies (which is important if you want to drive it well), you can leave your stuff in it, and you don't have to deal with the brown banana skin that the last user left in the passenger footwell.

Also, of course, the car companies weren't that impressed by the idea of selling fewer cars, and the sharing models on offer did not achieve the level of public buy-in or plausibility necessary to undercut the automotive industry's power. Consequently, the major automobile companies continue to advertise driving as a fundamental human right (not that we need to be reminded) and they still encourage the provision of cheap credit for vehicle purchases. The auto industry also continues to vigorously protect itself from competition from new entrants, holding up Tesla's early bankruptcy as an ongoing warning to those who try to sneak in to the market.

Getting around

We like driving, so we drive places. Of course, not everyone can drive but we've taken steps to ensure that anyone who is physically able to drive gets to do so. Driving and basic vehicle maintenance are compulsory subjects in schools and driving on public roads is legal from age 12. At the other end of our population, older drivers have to take a safety

test at age 90 and every 10 years after that, but we know how important driving is to their independence so we do everything we can to keep them on the roads as long as possible.

There isn't much public transport provision these days and most people wouldn't use it anyway; investing in something no-one uses would be a bit daft. Some people do walk and cycle for leisure, but that's usually in the safety of rural off-road environments. Most of the on-road bike lanes that were built in the past have been taken out to allow more space for cars (and because it really wasn't sensible to encourage people to bike on roads anyway). High speed electric bikes are popular with some of the older people who biked when they were younger, and they dominate off-road urban bike paths. Few children actually even learn to ride bikes these days and most progress directly from being driven by their parents to learning to drive themselves.

Cities and towns

Our roads are quite congested, but if you can afford to move out of the city a bit you can usually find somewhere that has good roads but isn't too choked just yet. Some people do keep moving to stay just ahead of the congestion but if you move a good way out you can get quite a few years of peace and quiet before the traffic catches up with you.

Parking in towns is a bit problematic, but malls in the outer suburbs mean you don't have to deal with that unless you have a really specific reason to head for the centre.

Health and wellbeing

We live in a pretty equal society in that almost everyone can afford to drive. There are some people who can't drive because they have some kind of physical or cognitive impairment though, and not driving is associated with considerable social stigma.

There is some state-funded paratransit for people who can't drive. It only covers 'essential travel' (which doesn't include much) and it's not very popular amongst users. It's definitely better than nothing but it usually doesn't allow those with impairments to work or to participate fully in the social and cultural lives of their communities.

Government policy

Our government prioritises economic growth and supports the large players in the auto industry. Regulation and taxes are low, because if they weren't, industry would leave New



Zealand for greener (less regulated) pastures overseas. Some people call this a 'race to the bottom' but our government prefers the term 'economic pragmatism'

3) Report summary and conclusions

This research aims to facilitate decision making about the future of transport in New Zealand. This document specifically focuses on the examination of the four scenarios, which are narratives that are designed to trigger debate about plausible future transport systems.

We have examined PESTLE (political, economic, social, technological, legal, and environmental) drivers that can influence two dimensions critical for the adoption of AVs: automation and consumption. This allowed to understand which factors can potentially promote or hinder higher automation and consumption. Further, we used workshops, discussion, and stakeholder consultation to develop four scenarios that inhabit the four possibility quadrants between the two uncertainty axes (automation and consumption). In result, we propose four scenarios: Custom Cocoons, Mode Nomads, Amped Autos, Active Scouts; which differ in their levels of automation and consumption.

What does New Zealand want from its transport future?

The scenarios may be more extreme than the reality that emerges. This was a deliberate choice because sometimes pushing beyond our everyday practical acceptance of the status quo encourages us to think about how things might be otherwise. Our scenarios, which were distinct from one another, internally consistent, and even somewhat homogenising of experiences, might belie the messiness of reality. For example, a double uncertainty matrix presents its extremes as mutually exclusive: automation is either high or low, it cannot be both. A situation in which highly automatous vehicles co-exist with driver controlled vehicles, and private car ownership and collaborative consumption complement each other in a multifaceted economic model, is highly plausible. In fact, we are confident that we will not witness the emergence of one new transport scenario or system. Instead we will see many subtly different variations emerging in different places and for different users. Between major disruptions—like the introduction of a new technology or a new economic model—transport systems will also continue to evolve, never really constituting an entirely stable scenario.

We have not and could not consider all the possible influences and drivers of future change. We recognise that there is a range of external influences to which we have not paid explicit attention.

Fundamentally, we have to ask what kind of society we want to live in, and whether a given change might help us to get there.

We have not considered changing climates, escalating electricity prices, global conflicts, stock market crashes, drones, hyperloop technology, or any of a myriad of other possibilities. We welcome readers to think about these and use the information we *have* presented to contemplate and discuss how other possibilities might work out.

What we hope we have done more completely is to demonstrate that a transition to autonomous vehicles would not be just a technological transition; it would be a

social one. While some research has focussed on what social change is needed to facilitate a transition to AVs (for example focusing on public acceptance of the technology or on the ethical and

legal challenges associated with it) there have been very limited considerations of what social changes might result. We have alluded to some possibilities—including changing social dynamics of communities and care—but there are many important questions that currently remain unexplored. Fundamentally, we have to ask what kind of society we want to live in, and whether a given change might help us to get there.

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