Regulation 2025
Emerging insights
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Ministry of Transport
TE MANATŪ WAKA

Ensuring our transport system
helps New Zealand thrive

New Zealand Government

Foreword

Hon Simon Bridges, Minister of Transport

New Zealand, on the edge

New Zealand has a heritage of innovation. A common saying here is that we can solve any problem with number 8 wire. This harks back to the time of the early European settlers. Far away from additional resources, they would find ways to use the standard gauge (number 8) wire used for fencing to solve any problem. This has created a generation with the desire to find simple, cheap solutions to problems or challenges.

This same spirit remains, recent examples of the culture of innovation in transport can be seen as New Zealanders' fitted out all of the major components for both of the boats in 2013 Americas Cup, kiwi ingenuity at the forefront of marine design. Another example is the development of the Martin jet pack, which is close to delivery of a commercially available jet pack, the Sci Fi dream of a millennium. Kiwis have spread this capability around the world, overseas; Ian Wright with this pioneering spirit has developed a gas turbine power system which halves the carbon output from trucks. Kiwis demonstrating their ability to be at the cutting edge of innovation in sea, air and land.

I am committed to do all I can to support this innovative spirit. To put in place regulation which supports entrepreneurs who will push back the boundaries in transport. I believe it is through innovation that we will see a transport system that will get us where we want to be when we want to be there. A transport system that will be safe for users and the environment alike.

I recognise that there are risks with new technology and I want to provide for an environment which will encourage innovation, but manage those risks to ensure we have the confidence to embrace new technologies.

This project considers the opportunities and risks ahead as new transport technologies emerge. I hope it will provide the starting point to create a regulatory environment which will attract international innovators to join us on the edge of the world as they work at the cutting edge of innovation.

Executive Summary

We have an exciting future ahead as we stand at the point of a paradigm shift in what is possible in transport. This revolution is timely, as we have created a transport system which has connected us to the world but at a cost. We face the challenges of managing congestion in our cities, preventing more than a million road deaths a year across the world, dealing with increasing levels of obesity, in part a result of being able to travel without physical effort, and a transport system which in 2009 accounted for nearly one-quarter of global energy-related CO2[1]. Technology, we hope, will allow us to have the benefits of travel without the costs.

We have to tread this path with care. When horses were the dominant mode of transport, the car was hailed as the technology which would allow us to remain connected while dealing with the mounting challenge of animal waste in our cities. As we look into the future we need to think not only of the benefits of the technology, but how to ensure that these do not come at an unacceptable cost.

In this work we explored both the potential impact of technology on the transport systems and also the degree to which we as a society might be willing to adopt new technology. This has allowed us to understand in more detail the risks and opportunities ahead. We did this with a view to understand the right approach to regulation of the transport system. Our key question was whether we could simply adapt the current regulation, or if we would need a new regulatory system to respond to the future transport system.

Key conclusions

The overall conclusion of this report is that the current regulatory framework could be adjusted to deal with the emerging transport technologies. The existing regulation allows for development to cover new risks and approaches to movement. Just as we have recently changed the law to accommodate remotely piloted aircraft systems, we could take the same approach for emerging smart and autonomous vehicles, and for the advent of the intelligent transport system.

While the system can be adjusted we will see the emergence of new risks - and also new tools to manage those risks. The risks and tools would be relevant across all modes. A cleaner approach would be to put in place a bespoke set of regulations which would deal with these common intermodal risks, perhaps with the creation of a new regulator for intelligent transport systems across the road, rail, air and sea transport modes. Taking this approach would avoid the risk that cross system issues slip between the responsibilities of the regulators of different modes.

The new regulatory system would be needed in addition to the existing regulation. The current regulation would continue to be needed to cover the physical aspects of transport while the new regime would cover the regulation of the “intelligent” aspects of the new transport system.

Key principles which would need to underpin the design of the new regulatory system would be to:

- enable new transport technologies
- allow for the management of risk from new technologies
- allow for monitoring and rapid removal of technologies which fail or create unacceptable risks
- facilitate the development of an integrated transport system
- provide for the protection and security of personal data and system integrity.

[1] International Energy Agency: *World Energy Outlook* (2009).

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Regulation 2025

We are facing a potential paradigm shift in the way transport services are provided. In this project, we explored whether we would need a revolution in regulation to match the changes we expect in the transport system.

In order to consider this question we first sought a deeper understanding of why we regulate and what influences change in regulation. We then considered what changes the transport system might face over the next 20 years. We did this by working with a wide range of stakeholders to produce a set of four plausible scenarios. The four scenarios explore how technology might develop and how society could respond. Refer to our companion document 'Scenarios summary and key findings'.

The goal of this work was not to come to a definitive policy position. Rather, we were exploring the potential opportunities and challenges ahead. The scenarios canvass these issues. This paper reflects our initial thinking in response to the potential futures ahead, and is designed as a think piece to stimulate debate as we consider how to position our transport regulation for 2025 and beyond.

The legitimate role of government

Kings and Queens were given their right to rule in exchange for an expectation that they would protect their people from force and famine. This relationship would break down if the rulers failed to provide adequate protection or ruled unfairly. While the immediate threats we face today are different, there is still an implicit contract between society and the government of the day. We expect protection and that the rules of law are fair – and this applies to transport just as it does to all other aspects of social interaction. We expect government to keep the roads safe, so we are happy for government to set the rules that should apply to all road users. We expect government to keep us safe as passengers of air transport, so are happy for the government to make it a rule that passengers are searched before getting on a plane – and we expect government to manage the natural environment, so are happy that standards are set for the emissions from cars. Each of these "protections", enshrined in law, removes an element of my freedom as an individual. The ongoing challenge for government is getting the right balance between protection and freedom.

PART 1

What drives change in the regulatory system?

Regulatory rules and systems are highly dynamic. The approach nations take to regulation evolves over time, by sector and by issue. This includes; the approach taken to institutional design, whether there is a need for independent regulation, whether self-regulation will suffice, the level of detail embodied in the regulation and the approach to enforcement of the regulation.

There are opposing forces within the system, some of which drive change in regulation, and some of which inhibit change. Some of these forces can both drive and inhibit change in the regulatory system.

Four key factors that drive change in regulation

- Changes in public perceptions of risk - for example acceptance that drinking and driving should be banned, or calls for increased controls in response to terrorist attacks.
- New regulatory ideologies - for example the move from prescriptive to performance based regulation.
- New business models - for example the development of platform technologies which have allowed new types of services such as Napster, which allows peer-to-peer music sharing or taxi type services.
- New technologies - which can both provide new tools to regulate, and create new issues to regulate, for example the development of the mobile phone.

Four key factors that inhibit change in regulation

- Social norms of established behaviours and culture - for example the view that speeding is acceptable with the right level of competency
- Regulatory inertia - whenever a law is changed it alters the balance of interests of who takes responsibility for the risks. This means that there are always winners and losers when regulation is changed. This creates two types of "drag" which means that it takes time for regulation to be changed. The first is a careful process taking the legislation through Parliament to ensure that changes are fair and effective. Designing and putting new primary legislation into place normally takes 3 years. The process goes through Parliament (which has limited time), which also means that change is rationed, so lower priority regulation may never make it forward. The second aspect of regulatory drag is whether the Government of the day has the political capital to make the change. As there are always losers (and winners) with a regulatory change the Government of the day needs to be confident it is reflecting society's views when pushing a regulatory change forward that will alter the freedoms of individuals and businesses.
- Established business interests - businesses make significant investments in capital and in building their reputation. They will quite reasonably seek to maximise return on their investments.
- Ludditism[2] - concern around the impact of new technologies on society. Some of which may be valid and others may not. Not too many years ago there were concerns that using a phone could "fry your brain", even though the amount of energy emitted from a phone is a fraction of that from sitting near a spot light.

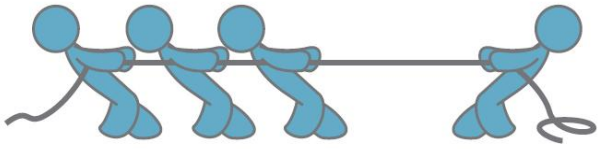
Figure 1: Factors driving and inhibiting regulatory change

Driving change	Inhibiting change
Public perception of risk	Social norms
New regulatory ideologies	Regulatory inertia
New business models	Established business interests
New technologies	Ludditism

[2] The **Luddites** were 19th-century English textile workers (or self-employed weavers who feared the end of their trade) who protested against newly developed labour-economizing technologies, primarily between 1811 and 1816. The stocking frames, spinning frames and power looms introduced during the Industrial Revolution threatened to replace them with less-skilled, low-wage labourers, leaving them without work. The Luddite movement culminated in a region-wide rebellion in Northwestern England that required a massive deployment of military force to suppress.

A good example of how these forces play out is in ship safety. In the 19th century, there were thousands of drownings each year when heavily laden merchant ships capsized. Cost cutting incentivised businesses to put as much cargo in their ships as possible and to hope for calm seas. The number of deaths eventually led to a social outcry. After ten years - the time delay highlights the influence of business interests - it was agreed that a maximum loading line should be painted on the side of cargo ships. This failed to rectify the problem, perhaps because the ship owners had painted the line on their own ships!

It was not until 1870's, when British MP Samuel Plimsoll investigated the effects of overloading, that the load line became a possibility, Plimsoll was concerned about the risks to the lives of the crews of so called "coffin ships", which were unseaworthy, overloaded and often heavily insured vessels. In 1872, he published a work entitled 'Our Seamen', which became well known throughout the United Kingdom. Plimsoll was defeated several times in Parliament but eventually an Act was passed in 1876 that required a series of 'lines' to be painted on the ship, to show the maximum loading point. These became known as the Plimsoll lines. Unfortunately, the Act gave ship owners the discretion to paint the line where they saw fit. The position of the line was not fixed by law until 1894. This story is a perfect example of the balance that is struck between risk and reward, with the Government of the day having to balance the interests of different groups.



Regulation can also drive change

Regulation is not simply a response to change; it can also be put in place as a force to drive change. There are two good examples of how this works in the transport sector.

Businesses seeking to build on minimum regulatory standards

In the car industry, the government sets minimum standards for the safety of vehicles. There are also star rating systems which provide consumers with an indication of relative safety above the minimum standards. The vehicle manufacturers innovate as a means of attracting customers to "premium" products. A good example was the development of ABS in the 1980s. Mercedes-Benz were one of the first to introduce this into their top model. Once established as an expectation within luxury cars by all car manufacturers, the technology was increasingly offered in many less expensive cars. Some governments then made it compulsory for all new vehicles to have ABS.

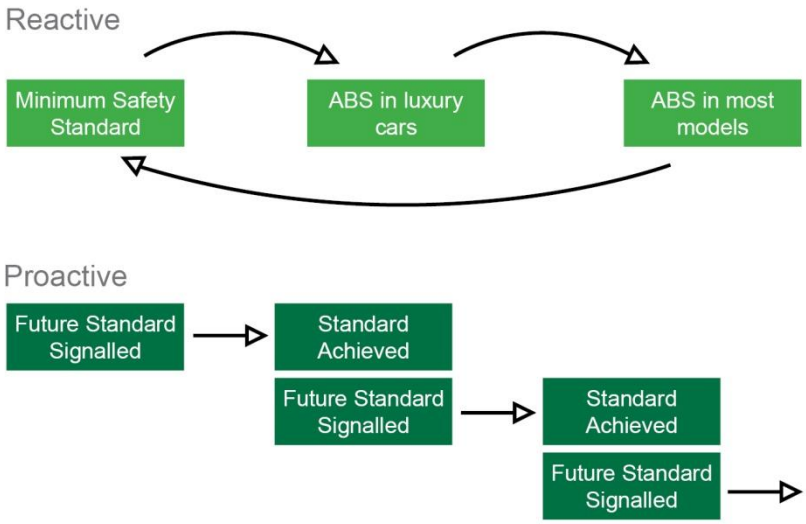
This shows how incentives and regulations change over time. At the start, some businesses want to be allowed to bring in additional technology to enhance their market positions (in this case they were allowed – there was no regulation that stopped it). As the technology became more widespread, the costs came down and other businesses adopted it. The lower costs also made it easier for the government to mandate the technology, and society benefits through overall improvements in safety.

Government setting a target for minimum standards

Another example of where regulation drives change is where regulation has been put in place to drive improvements in air quality. In this case, businesses did not have an incentive to innovate on top of a basic standard. Government instead set a target for lower emissions, with the regulation coming into force 10 years later. This provided a focus for business innovation and allowed the industry time to adjust to the new targets.

Both of these examples demonstrate how government can drive innovation or its application through the wise use of good regulation.

Figure 2: Regulation can drive and respond to change

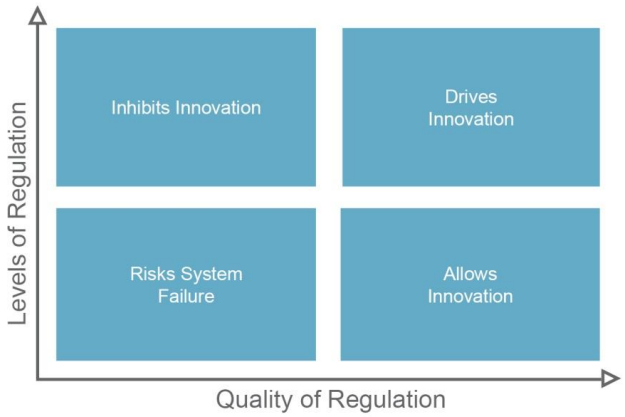


Good versus bad regulation

Some argue for a cautious approach to new technology, using the rationale that regulation should be in place before new technology is sold, to ensure we get the benefits but minimise any harm. This approach can inhibit innovation as businesses have to wait while regulation is put in place. Businesses are also limited – only able to innovate within what is allowed for in the regulation. On the other hand, it is possible to provide an open field for innovators to make sure that there is no regulation that would prevent progress, though this means any negative effects need to be addressed after they have arisen. Views vary on which approach is the best, and typically legislation needs to be designed to match the type of risk being managed. The real question is not whether to regulate ahead of or after a new technology arrives, rather it is to ensure that good regulation is put in place.

Poorly designed regulation inhibits innovation, and often leads for calls to minimise regulation. If done well, light levels of regulation allow for innovation. Equally, if light regulation is managed poorly, it can lead to system failure. Recent examples of this are the global financial crisis and leaky homes. In the latter, the rules for the building of homes were relaxed and builders used poor quality materials and poor building practices for a decade - affecting between 20,000 – 90,000 houses. In both examples, the harm was the result of a false assumption that allowing markets to self-correct would provide the best outcome. The key point is that the goal should be to design high quality regulation and not to get caught by a regulatory philosophy that it is always better to take one approach to regulation.

Figure 3: Good vs bad regulation



PART 2

What changes will the transport system face over the next 20 years?

We have developed a set of scenarios which cover all transport modes (road, rail, air and sea). However, the area where we are likely to see the most significant change is in land transport. As a consequence, it is useful to consider land transport when we are thinking about how we will need to regulate transport in the future.

We are facing a potential paradigm shift in the way land transport services are provided. This is being driven by significant advances in technology, creating the potential that we will see:

- self driving vehicles
- platform technologies which support new business models
- sensing technology which allow us to know where everything is and
- data management systems which allow us to optimise the performance of the transport system through modelling the impact of interventions and also real time system optimisation.

Throughout this document we discuss 'autonomous' vehicles. These are commonly known as self-driving vehicles. There is already a wide spectrum of vehicles with technologies that assist driving, improve safety and reduce travel time costs. The level of assistance differs including:

- driver assistance such as proximity warnings
- features that enable partial control of a vehicle such as cruise control and advanced cruise control where the driver steers but the car brakes automatically and accelerates back to the set speed when safe to do so
- technologies to wirelessly share information with other vehicles e.g. data on traffic and hazards
- technologies to share data with infrastructure e.g. traffic lights.

Some manufacturers are developing vehicles which can self drive for specific settings such as on motorways or in urban environments, though with the option of the driver taking back control of the vehicle. Others are developing completely automated vehicles. Eventually their goal is to produce vehicles capable of self driving in all situations with no steering wheel needed in the vehicle. In this document, when we refer to self driving vehicles this refers to situations where the vehicle is performing all of the tasks necessary to drive.

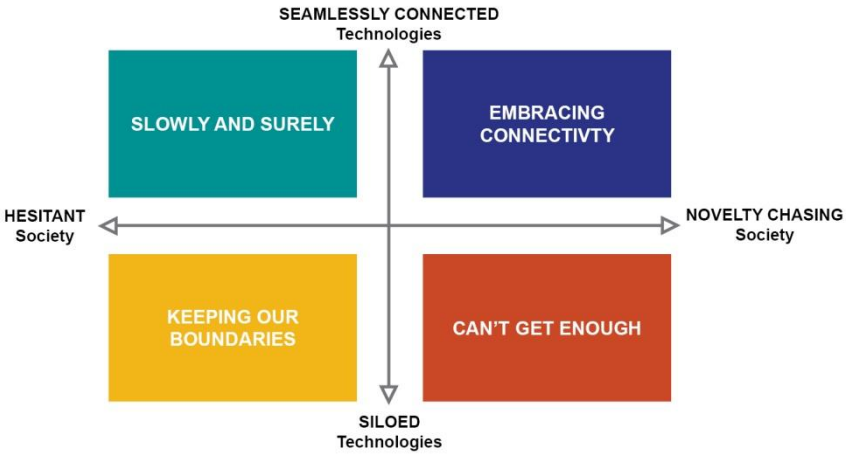
The key question we need to consider is whether we will be able to adapt the existing rules to meet these changes, or whether we will also need a new paradigm in regulation to meet the new paradigm in transport.

While these new technologies will be available, it is uncertain whether they will be adopted, and what the extent of their adoption will be. In order to better understand what the future could hold we developed four scenarios of the future. The two factors which we thought would have the most significant effect on the future of the transport system and the way we regulate it were:

1. Whether society will want technology which assists us in our vehicles or whether we will be happy to use self-driving vehicles, ie will we be *hesitant* in the adoption of the new technology, or will we embrace the *novelty* of the new technology,

2. Whether the transport system will move from many self-contained systems, to a fully integrated system with complete and seamless transfer of information across the whole system, ie *seamless* systems versus *siloed* systems.

Figure 4: Our four scenarios



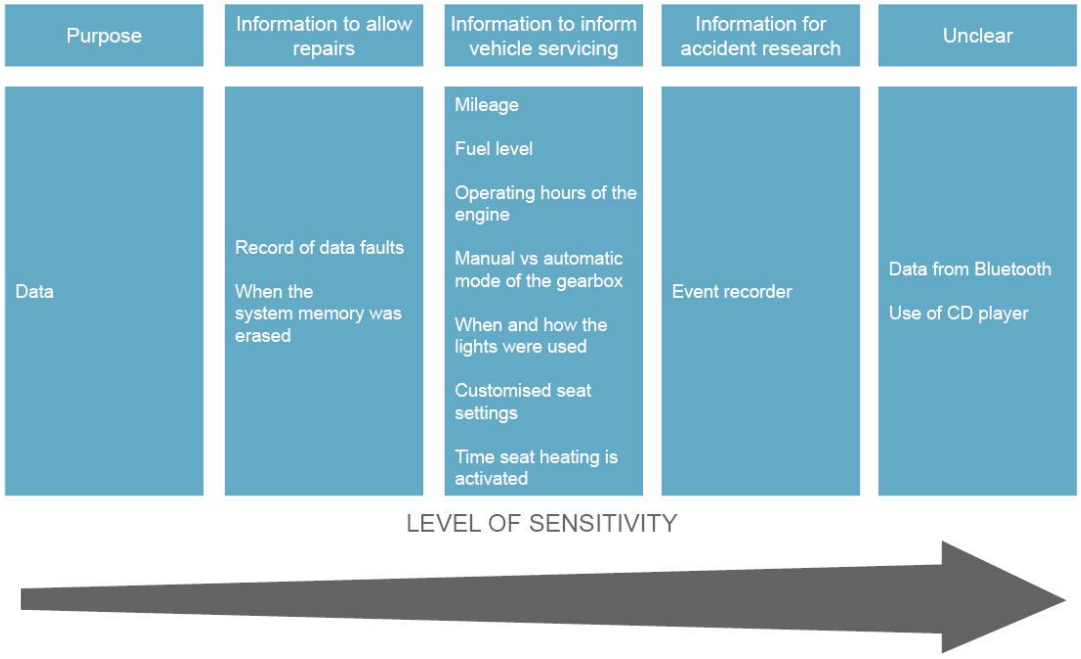
The four scenarios we have developed propose two worlds (right hand side) in which society values the utility of new technology over any associated risks. We have already seen this with the mobile phone – we all have one because of the value they provide us, irrespective of potential concerns around privacy and security of data. In one of these worlds (Embracing connectivity) there is seamless integration of all technology. This allows for changes in the way transport services are provided. In this world, we move from owning our own vehicles, to paying for the use of self-driving cars owned by fleet operators. This is commonly referred to buying mobility as a service.

In the second of these scenarios (Can't get enough), while self-driving vehicles are available, lack of integration means we still own our own vehicles and movement is not as well managed across the network.

In the other two scenarios (left hand side) society values staying in control and avoids security risks. This means that while we are happy to have technology which assists us in our vehicles, we do not want technology which removes control of either the vehicles or the data which is collected when we use the vehicles. In the first of these scenarios (Slowly and Surely) the transport system is integrated. This supports a shift towards ride-sharing, as we find other ways to drive the efficiency into our transport system, other than use of self-driving vehicles.

Figure 5 provides an overview of the type of data that is currently collected by vehicle manufacturers.

Figure 5: Summary of data collected by vehicle manufacturers



ADAC Test and Technical Services: What data do today's cars collect, store and transmit? (2015)

Can we adapt the current law or will we need new law?

The key question this project seeks to answer is, whether we can simply build on existing regulatory frameworks in response to these changes or whether we will need to take a new approach to regulation – or, in other words, 'how should we regulate transport in 2025'?

Regulation of self-driving cars

While some developed nations have come to the view that they cannot allow AVs on their roads, this is not the case in New Zealand. In New Zealand, the law is permissive and does not require a driver to be behind the wheel of the car.

This means that technology, which either assists the performance of the driver or takes over from the driver, can be used in New Zealand. The scenarios have, however, highlighted that we will face a number of new risks if this technology were to be offered for use by the public.

New risks - potential areas for regulation

Ensuring the fitness of the driver to own and operate the car

At the moment we license people to be able to drive. This would not be necessary in a self-driving car. However, we might decide we want to regulate for use instead. Owners would need to get a licence to use a car, just as people get licenses to own and use a firearm. The test would change from a test of skills to one of character, to ensure that the owner will use the vehicle responsibly.

Regulating the 'black box' which drives the car

At the moment companies are trialing their technology, driving tens of millions of kilometres to ensure that their technology, i.e. the 'black box' is safe. We cannot use this approach to test each vehicle if self driving cars were being sold to members of the public. In New Zealand, we trust overseas manufacturer standards for vehicles. However, where software is concerned we may want to have greater certainty that vehicles entering the New Zealand market are safe. As a result, we will need a way to test the software, to check it will make the right choices, will comply with the law, and is stable.

Trials of self-driving vehicles have shown that the current law can make it difficult for software to operate effectively on the roads. There are situations when it is only possible to get from A to B by working around the law. We, as humans, will know when it is right to do this. For example, where a truck is parked on the road to repair it, we would not sit in our cars and wait for the road to be repaired and the truck to move. We would cautiously cross the double yellow lines to pass the vehicle, as we are better able to understand the intricacies of following road user rules.

Regulating a self-driving vehicle to operate safely on the road is complex. Regulation will either need a growing number of "what ifs", or to allow for some flexibility of how to perform safely on the roads so that the software can make a judgement of when it is safe to work around the law. This will make regulatory design challenging, and also highlights that we will not be able to assume that self-driving cars will follow the "letter of the law" even though they may be better than us at following the "spirit" or purpose of the law to ensure safe outcomes.

Regulating fleets of vehicles

We will also want to be able to regulate for a fleet, as well as for the performance of individual vehicles. Emergent behaviour[3], sometimes good and sometimes bad, is seen when a large number of individual players interact. Even though the rules each player operates to look good, the interactions when all follow the same rules can be surprising. This means we would need to find a way to manage the whole system to ensure we did not experience a system failure.

Transitional issues

While these are all new issues, which will arise as we move from technology which assists us to technology which drives for us, the boundary and timeframe between the two is unclear. There will be many transitional issues.

We even face challenges, as drivers, switching between existing manual and emerging assisted technologies in cars. Our assumption of assistance could lead to an accident. An example is the car's internal flashing lights, which let the driver know if there is a car in the blindspot before overtaking on a dual carriage way. If a driver is used to driving with such a warning, moving back to a car without this facility may result in inadequate checks of their blind spots. There are many equivalents with other types of technology that help the driver, such as park and brake assists, and proximity warnings.

We expect to see the eventual introduction of regulation for assisted technology. Some regulators will follow the ABS example described previously, with the technology eventually becoming compulsory. But as we move closer to the border of ceding control to the vehicle, the assisting technology also brings risks, where we may want to regulate use or regulate against use.

An example of regulation against use is prohibition of connected vehicle technology in the 760 MHz bandwidth. This is the band-width which has been adopted in Japan for connected vehicles. In New Zealand this bandwidth has already been allocated for telecommunications, and any connected vehicle operating on this band-width in New Zealand is illegal because it would create interference to the licensed telecommunications network. New Zealand will also need to manage the risks of disruption from diverging technology standards between the United States and Europe, as well as with Japan.

For cars that have additional features, which can self-drive in limited circumstances, there are other challenges. The key challenge is how the driver will know when to relinquish, or take back, control of the steering wheel? Manufacturers have developed some innovative approaches to signal the changes to the driver. The key issue for us, however, is to consider whether there will be a need to regulate for use of this technology. Would the users of these vehicles need to demonstrate that they can effectively transition their vehicle from normal to self-drive mode? How would the vehicles be tested to provide assurance that they would only self-drive in the areas where they have been designed to operate in that mode?

[3] *https://en.wikipedia.org/wiki/Emergence*

An emergent behavior or emergent property can appear when a number of simple entities (agents) operate in an environment, forming more complex behaviors as a collective. If emergence happens over disparate size scales, then the reason is usually a causal relation across different scales.

We can respond to these issues and risks in three ways

1. Leave the legislation as it is and add in additional law if risks materialise.

A previous example of where government took this approach is the mobile phone. It was only when it was widely apparent that it could distract the driver did we regulate use while driving.

2. Rely on international law to manage these new risks.

We already do this for planes, and could take this approach to all vehicles. While the approach might work for aircraft, could we be certain that cars and trucks sent to New Zealand would meet the same standard as those manufactured for the country of origin? We could say that these vehicles had to meet our standards and enforce this requirement. However, there are already diverging standards overseas for vehicles. This poses the question whether in the future, an international standards organisation would be needed.

3. Introduce domestic legislation to manage these new risks.

If we were to do this we would need to design the law well so that it supported the development of innovative technologies. It could, for example, allow new technology to be trialed and then made available, but require the company to have insurance to cover any resulting harms. Two further steps might be put in place. The first is for vehicles to record details of their movements, to allow quick determination of whether it is the vehicle or the operator who is at fault. Secondly, this could be combined with new enforcement, which allows the immediate recall of vehicles if there is a risk of more widespread harms.

Regulation of integration (integrated systems)

While many of the technologies will work on their own, effective integration of the technologies will see significant additional benefits. For example, if all road users tell other road users where they are, it will improve safety outcomes and facilitate ride-sharing. However, it is not always in the best interests of a business to allow its system to be integrated with others. It certainly requires complete confidence in the systems of others to do so. We will need to consider carefully whether we are likely to get an *integrated* intelligent transport system through market forces alone. If not, we may need to intervene before markets become entrenched in approaches which prevent future integration.

We can respond to integration issues in three ways**:**

1. We can leave it to the market and hope that the market will find the right solution for how to integrate and the level of integration.

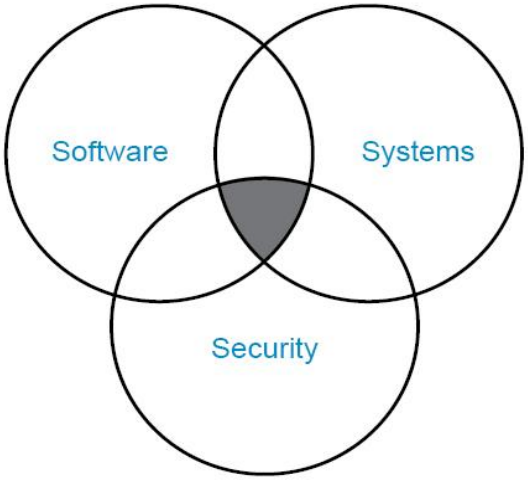
2. We could leave integration to the market but set standards for communication, data accessibility and security.

3. We could regulate for integration and perhaps even go as far as to provide some of the underlying ITS infrastructure for open use by all road users.

What risks would need to be managed if these technologies become widely adopted?

There are three categories of risk we would need to manage for: software, systems and security risks. These three areas overlap, but it is worth separating them out so that we do not miss any aspects.

Figure 6: New risks – potential areas for regulation



Software

We would need to have confidence that the software which controls autonomous vehicles would deliver the performance we expected. The previous section has highlighted why this will not be straightforward as we move from trialing self driving vehicles to offering them for use by the general public. Not least we will need a regulatory system which provides assurance that each vehicle's software is effective and stable, and that it is "fail safe". Add in to this the complication that different countries are already setting themselves different goals for their regulation. One country is planning to allow self-driving vehicles on its roads as soon as they are safer than cars driven by humans. Other countries will allow them if they are "safe", what bar will be set if this is not clear (does it mean they will never crash?) We need to watch this space carefully as there are significant industrial reasons for countries lowering the bar, including to give car manufacturers in their own country the opportunity to enter the market early.

Ethics and software

There is much debate in the media about how self-driving vehicles will decide which life to save - if there is a choice - in an accident. For example, how would a vehicle decide between a head on collision which is likely to lead to the death of the driver, or to swerve and hit two pedestrians which may lead to one or both of their deaths. The debate centres on the ethics of software making a decision on which risk to take. If left to its natural course it is likely that it will follow one pathway to the way that the software will be programmed to respond to this situation. Before setting out this pathway, it is important to understand the context for the approach the programmers are likely to take.

In a world of autonomous vehicles, it is likely that the number of fatalities will be far fewer than today, some have estimated that the number will drop by 90 percent. Worldwide this would be an annual saving of more than a million lives. If this were the case, it may be a prize we do not want to miss out on, whatever approach the software takes in deciding the relative importance of one life over another.

Now to return to the question – how is the software likely to be programmed if we leave it to the market to decide? Let us explore this with an example. If you are choosing to buy a car will you choose the one which favours the life of the driver or the one which favours the life of the pedestrian? The consequence is that there will always be a strong incentive on the manufacturer and the users to prize the safety of the driver more highly.

The question is more complex, as the software will balance risks and potentially also the life of the driver with the lives of several others. If we take a utilitarian approach we would expect the software to choose the options that lead to the least harm. Given the incentives on us to buy the car safest to ourselves rather than society, ensuring software is programmed in this way may require regulation.

System issues

If we have an integrated transport system - whether for land transport or all modes of transport - we will need to have confidence in the system's stability and performance. This will present different risks to manage, which needs deep expertise in system behaviour. We know from biological systems how there can be both positive and negative emergent behaviour, as well as some neutral emergent behaviour like patterns of swarming birds. The regulators would need to be able to regulate for fail safes, tragedy of the commons[4] and other system behaviours.

There are ten commonly seen archetypes of system behaviour, some of which would apply to transport systems. Regulators would need to develop an understanding of how systems can behave and how best to respond to changes in system behaviour.

Figure 7: 10 Archetypes of System Behaviour

The System Archetypes by William Braun.

We will also need to ensure that any software is compatible with the wider transport and communicatons systems including communications technologies, enforcement technologies and system management technologies.

[4] Example of 'tragedy of the commons' - Traffic congestion

Public roads are an excellent example of common property shared by many people. Each of these people has his or her own interest in mind — typically, how to get to work as quickly and easily as possible. But when everyone decides that public roads are the best way to meet travel needs, the roads jam up and slow down overall traffic movement, filling the air with pollutants from idling cars. Turning public roads into private roads or toll roads creates a different scenario. With a toll to pay (especially if the toll is higher during peak-use hours such as rush hour), drivers may consider a less-direct route or choose to drive to work at a different time.

Security

Security will cover both physical and data safety. A high standard will be expected to protect from hackers taking control of vehicles or taking personal data from the systems. Much concern has been raised on these issues, and the strong interest for vehicle manufacturers to make this work should provide sufficient incentive. It is still likely, however, that regulation will be expected for the protection of personal data, and the protection of certain areas from self driving cars – such as the runways of an airport or inside shopping malls. Geo-fencing[5] is an approach to protect areas from autonomous vehicles. While reserved at the moment perhaps to protect essential facilities, we may see geo-fences become standard parts of home wi-fi systems. If such technology did become available, it would be possible to disrupt key parts of the network. We would also expect to see regulation for compensation against inadvertent disclosure of data.

Insurance and liability

Much has been written about the changes that will be faced by the insurance industry if we move to a world where there are only self-driving vehicles on the road. Some commentators speculate that autonomous vehicles will eliminate the personal car insurance market. Although New Zealand does not have compulsory insurance, we need to look at this issue carefully before we jump to any conclusions on the future of the insurance market for land transport.

Insurance is a way of managing risk, so the key question which needs to be addressed is whether we think that all risk will be removed from land transport movements. The answer to that question is surely, "no", attested by the fact that there are as many discussions about who will own liability as there are about the demise of the car insurance market. As discussed in previous sections of this paper, while the risk of human error in the operation of the vehicle will be reduced with automation, many risks will still remain. While the driver might not crash the car, the vehicle might crash, be damaged, or cause damage. The risk of this occurring might decrease, but additional risks arise, particularly around data security and system performance. We may have more individual crashes when humans drive, but with software in control, there is a new risk of systems failure. This might be a very rare event, but the consequences could be significant.

As a consequence, it is likely that there will continue to be a need for vehicle insurance – including manufacturer insurance against software malfunction. People are still likely to want to insure their vehicles for theft or fire. The nature of the risk insured will change and the value of the market would change to reflect the nature of the risk, but there would still be a market for vehicle insurance. The way this operates will vary depending on the model of ownership in the future. If vehicles are run as fleets, with individuals buying mobility as a service the fleet owner could self-insure or buy insurance. If ownership models remain, then we would still need vehicle insurance to cover ownership and use of the vehicle and the manufacturers might buy insurance to cover system risks.

Sitting at the heart of this issue is the debate of where liability would lie in an AV world. This is a matter of choice; we could elect to regulate to require the owner to take the risk or equally we could regulate for the manufacturer to take the risk. The market will then respond with the provision of suitable insurance to cover those risks. Of course, it is not quite as simple as this. The harm might occur as a result of improper use or a failure in the design or manufacture of the vehicle. The normal principles of law would apply to assess where the fault lies. We could simply rely on common law to ensure there is an appropriate remedy whenever harm arises. The market would respond to this with the necessary insurance products to allow us to manage those risks as individuals or businesses.

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[5] *https://en.wikipedia.org/wiki/**Geo-fence***

A **geo-fence** is a virtual perimeter for a real-world geographic area. A **geo-fence** could be dynamically generated—as in a radius around a store or point location, or a **geo-fence** can be a predefined set of boundaries, like school attendance zones or neighbourhood boundaries.

The transaction costs of relying solely on common law to resolve disputes could be high as the market seeks to establish itself around early case law. It would be possible to reduce the transitional costs of moving to the new regime by legislating for levels of insurance to be held by the owners and manufacturers of the vehicles. That way, where there was uncertainty of who is at fault, the legal debate would be between two insurance companies, allowing the individual user to enjoy use of AVs without having to manage such uncertainties.

To regulate or not regulate, that is the question

Our scenarios have highlighted the very dynamic nature of the future. Whichever world we find ourselves in, there will always be pressure to move into another one of the scenarios. The more extreme position in any of the scenarios, the greater the pressure to change. For example if we are in a world where we place opportunity over risk, there may come a time when this backfires and a risk materialises. This could push us society to change its priorities, and value management of risk over opportunity.

This means if we, as a society, have a preference for a scenario we would like to remain in, we can regulate to facilitate that. The top right world (Embracing Connectivity) is one where we see the benefits of self-driving vehicles and integration. Initially, a very light touch regulatory regime might be needed to allow for innovation in self-driving vehicles. However, to stay in that world, it may over time be necessary to introduce a regulatory regime that manages associated risks to maintain consumer confidence and ensure the focus remains on securing further utility from the technology. Regulation might be needed on data security and disclosure of performance to encourage innovation that further improves the outcomes. We might even see a world where self driving vehicles become compulsory for all new vehicles, just as we have seen with ABS.

As the regulation would be in new areas of software, systems and security, we will need to ensure that the regulators have the new skills and tools for their trade. The risks are likely to be common across all modes; this suggests that for a small country like New Zealand, it could be better to have a single piece of legislation with a single transport regulator managing these new risks across all modes.

This regulator would not replace the existing regulators. In the first instance, the new regulator would need to be in addition to the existing regulators, as we transitioned to a new transport paradigm.

We are not an island

As we consider which path to take on regulation, the scenarios have highlighted that it is likely different groups of countries will end up in different quadrants. Some will take a more careful approach to the adoption of AVs and integrated ITS. We see similar divides for financial regulation, with countries taking different approaches to the regulation of financial products. If this happens, more cautious countries may not want vehicles from other countries imported, or will expect modification before use. Equally, manufacturers may not want to risk their brand in a lightly regulated market. One reason for regulation is to give other countries confidence. On the other hand, strong regulation may reduce the competitiveness of a country if it cannot take advantage of the latest ITS.

When would we need to have new regulation in place?

This project looks ahead to the challenges we will face from 2025 onwards, so we could continue with the current legislation, and only make changes if risks materialise. Alternatively, we could take a more proactive approach. With two potential goals – minimising risk and pushing for advances in technological progress – finding the right balance is the key strategic regulatory choice we face for New Zealand's transport system.

That said we will need to watch this carefully as there is no clear delineation between what is assisted technology and what is self-driving technology.

Conclusions and a future path

In this project we considered what regulation we should put in place in the transport system to respond to changing technological opportunities and social expectations. We started by producing a set of plausible scenarios, exploring how the transport system (and regulation as part of that system) would develop over the next 20 years. These scenarios are tools to help consider the challenges and opportunities New Zealand will face. This report reflects some of the initial thinking as we reflect on the implications for regulation in those scenarios.

The most significant technological changes we will face in transport are likely to be the:

- ability of vehicles to control themselves, whether on the land in the sea or air and
- development of an intelligent transport system, which will allow for the effective co-ordination of the system matching our needs to the services which are offered.

The legislation we currently have in place puts no additional regulatory expectations on operators of self-driving vehicles. This will encourage innovation and support the development of technologies which will help to address congestion, road safety, equitable access and environmental impacts of transport. But the new capabilities come with new risks. We developed a set of plausible futures to understand how the risks and opportunities might play out. These scenarios highlight that the way society balances the potential benefits of the technologies with the associated risks will determine what our transport system will look like. One key role of Government will be balancing these risks and ensuring we maintain society's confidence in the widespread use of these new technologies.

The three key areas of risk that are likely to emerge relate to:

- software, ensuring we maintain confidence that the programmes controlling autonomous vehicles will perform safely
- systems integrity, managing the way the overall systems perform; and
- security ensuring the data and transport is safe from hackers or other activities that intentionally or unintentionally destabilise data.

We can take one of three approaches to respond to these risks in our regulatory settings, we can:

1. keep current regulation and build on regulation to respond to risks as they materialise
2. rely on international standards to ensure that the vehicles on New Zealand's roads are safe or
3 put in place additional regulation now to manage these risks.

A future path

To be in a position to respond to technology and encourage innovation there are a number of potential steps that can be taken. These steps are not necessarily sequential and could be in parallel.

1. Ensure there is an open regulatory system which allows for the development and deployment of new transport technologies. This should be backed up with the ability to be able to respond quickly to deal with risk. This ability to respond quickly is needed today, as we find out how people adapt between vehicles with different levels of capability. In order to allow the regulators to react swiftly when required, we should consider what regulatory tools they will need, and also what access they will need to data from the new technology.

2. Once the path of innovation is clear, we could rely on international standards, supplementing this where there are gaps with the development of a new regulatory system to manage the new risks around software, systems and security for all modes of transport.

3. An integrated intelligent transport system is critical to help manage the increasing complexity of the transport system, and our interactions with the system. This is unlikely to happen without government intervention for three reasons:

    i. The **transport system is made up of a number of different sub-systems**, for example the system which manages movement of vehicles in the public transport system, and the system which collects payments from road users. While the market might, over time, deliver integration for individual markets, it is unlikely that without regulation all the systems will be integrated.

    ii. The **value of data**. Even if there is the potential for all systems to communicate there is money to be made from the sale and use of data. This would mean that some players in the system would want to keep data for their use or only on sell at a price the market will not bear.

    iii. Concerns about **how to maintain the security and integrity of data** across multiple sub-systems.

4. A key consideration is the need to be front-footed in the regulation of the data required to run the emerging intelligent transport system. The first stage in this process would be to undertake a detailed review of what data is likely to become available, and what data will be needed in order to run an intelligent transport system.

Concluding statement

The overall conclusion of this report is that the current regulatory framework could be adjusted to deal with emerging transport technologies. The regulation allows for development to cover new risks and approaches to movement. Just as we have recently changed the law to accommodate remotely piloted aircraft systems, we could take the same approach for emerging smart and autonomous vehicles, and for the advent of the intelligent transport system.

While the system can be adjusted, we will see the emergence of new risks and also new tools to manage those risks. The risks and tools would be relevant across all modes. A cleaner approach would be to put in place a bespoke set of regulations which would deal with these common intermodal risks, perhaps with the creation or a new multi modal regulator of intelligent transport systems. Taking this approach would avoid the risk that we do not put in place a comprehensive regulatory system to deal with the new systems.

The new regulatory system would be needed in addition to the existing regulation. It would need to allow for the parallel regulation of the two paradigms of transport. The current regulation would continue to be needed to cover the physical aspects of transport, while the new regime would cover the regulation of the "intelligent" aspects of the new transport system.

Key principles which would need to underpin the design of the new regulatory system would be to:

- enable new transport technologies
- allow for the management of risk from new technologies
- allow for monitoring and rapid removal of technologies which fail or create unacceptable risks
- facilitate the development of an integrated transport system
- provide for the protection and security of personal data and system integrity.