# Technology related transport skill requirements and availability

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# Changes made to version of report published in March 2018

Page 69, Section 7.5.1 – MITO New Zealand Incorporated correctly named.

Page 69, Section 7.5.3 – Second paragraph deleted.

Page 70, Section 7.5.4 – Sentence deleted.

Page 71, Section 7.5.6 – Dot point three – second half of sentence deleted.

Page 77, Table 8.2 – Driver occupation group total, 2020 count corrected.

Page 81, Table 8.5 – Driver occupation group total and Repair and maintenance occupation group total, counts corrected.

Page 93, MITO New Zealand Incorporated reference corrected.

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# Contents

# Executive summary

This report presents the findings of research, conducted in 2017 in New Zealand to:

- identify intelligent transport systems (ITS) technologies likely to be desired in 2035
- identify the associated industries, skills and occupations
- estimate the consequent employment demand in type (occupation), quality (skill) and quantity
- estimate gaps in these – assuming current trajectories of employment and qualification attainment
- assess the role of training establishments, migration and ageing of the workforce in influencing the gaps.

The economics and engineering literature provided a conceptual framework about how:

- innovation, communication, the time period and the social system influence technology uptake
- technology change influences the demand for certain skills
- occupations consist of a basket of various skills
- the demand for new skills influences the demand for new qualifications and training
- occupations evolve as they emphasise newer skills.

The evidence on expectations for technological change to 2035 and the consequent impact on skills, training and occupations was collected from:

- expert views of academics, industry and consultant engineers and economists
- responses from questionnaires to industry stakeholders
- stakeholder workshops convened in Auckland and Wellington covering about 40 people
- global and local perspectives drawn from an extensive literature review.

The following is a summary of the findings.

## ITS technology scenarios for New Zealand

By 2035, ITS implementation will likely result in a limited take-up of ITS technology associated with:

- a high level of semi-autonomous vehicles, up to about 37% of the national vehicle fleet at Society of Automotive Engineer levels 2 to 4 of autonomy
- a low level of fully autonomous vehicles, up to about 15% of the vehicle fleet, but concentrated in controlled domains
- a proportionately greater take up by businesses and passenger fleet businesses than households
- a lower motor vehicle crash rate overall due to the enhanced safety benefits that semi and full autonomous guidance provides
- a sizeable proportion of transport management dedicated to supporting controlled domains and to developing new ones
- a widespread take up of information and communication technology (ICT) associated with both embedded and nomadic telematics.

## Skills gap assessment for New Zealand

A deficit in supply of skilled workers to match new areas of demand associated with the implementation of ITS, is expected by 2035, assuming current trajectories of supply continue.

In summary, our qualitative skills gap assessment is:

- Current occupations will likely still be in demand, but skills required of them will change significantly.
- All occupations will require skills to access and operate on-line tools and on-line resources, though with the development of the internet of things (IoT) such skills may be ubiquitous by 2035.
- Commercial freight drivers and passenger transport drivers will likely require new skills to operate near-autonomous vehicles in controlled environments.
- Automotive technicians will require new skills to maintain complex high-technology devices in vehicles. Some of these skills may be specific to particular brands and models. They will likely need to operate computer-based diagnostic equipment and interact with specialists locally and on-line.
- Professional and technical engineers in industry and public sector organisations will need new skills to enable their collaboration in multidisciplinary teams with others from diverse disciplines to provide user friendly and people-focused transport solutions. They will need skills for addressing transport environments as systems involving people, infrastructure and connected mobility outcomes. They will require human-centric skills to complement their science, technology, engineering and mathematics (STEM)-based skills
- ICT professionals and technicians, like engineers, will need collaborative and human-centric skills. Data analytic skills will be in high demand, but coupled with skills for creativity and design. In addition, skills will be in high demand to create new solutions for people, to provide connectivity of embedded telematics in vehicles with other devices, cellular networks and the cloud.

## Training needs assessment for New Zealand

The new environment of ITS technology calls on diverse leadership across the transport sector:

- Students are called upon to actively seek opportunities to broaden their training to acquire skills that enable them to collaborate with other skilled workers from different disciplines.
- Training organisations need to be flexible to accommodate new skills demanded, but must adhere to clear pathways for careers, that are co-defined with industry.
- Business has a clear role to define skills required currently and to engage in activities to assess future skills required.
- Original equipment manufacturers have a role to provide knowledge bases about their technologies to training organisations and to businesses to enable effective training.
- The government has a role to provide incentives and to reduce barriers in all these interactions.
- The government has a role to build public awareness at all levels, from school age to adult on the future of ITS and its implications.

Training for transport professionals and technicians will need to encompass a wider field of codified knowledge as well as provide skills to carry out tasks in rapidly changing systems. Training for them will also need to focus on skills to enable collaboration with skilled workers in wider fields. There will need to be an emphasis on continuous learning to address changing skills needs. Current skills shortages for these professionals is a risk to the achievement of future ITS implementation.

Motor trade technicians' training must address the current chronic shortage of skilled technicians before attempting to target the need for long-term skills. Primarily this is because future skilled workers are necessary to train future apprentices on the job. While cross-sector collaborations between industry and training organisations are currently in development, there is a need to deepen these to provide a greater emphasis on delivering apprenticeship training and to provide clear training pathways. Introduction of new technologies under ITS will necessitate action by manufacturers to provide knowledge bases to trainers, both in training institutions and in the workplace.

For ICT professionals and technicians, there is also a chronic shortage of skilled labour that presents a risk to the achievement of ITS implementation. Like engineers, future training for these professionals will need to emphasise delivery of human-centric solutions. Big data is important to ITS and the recent introduction of data science courses at tertiary institutions that link conventional computer science and statistics is an important step to provide skills to operate in big data environments. Flexible training to accommodate diverse human-centric perspectives can be achieved without formal credentials, hence the essential ICT skills are enhanced quickly and easily to enable collaboration with other fields.

Industry leadership in assessing and delivering training needs is essential. ITS firms precisely understand the current skills needs. By establishing codified learning courses in collaboration with training providers, industry can set the short-term learning agenda, from which the long-term agenda can evolve. By creating workplace learning opportunities, firms can build the absorptive capacity of their new and future workforce, so that they can continually upskill as ITS implementation evolves.

## Projections to 2035

Employment projections to 2035 were prepared for workers in 55 occupations, selected as relevant to ITS implementation. Baseline projections, assuming demand for skilled workers is met by supply, were prepared for the 55 occupations. In addition, projections of employment for them were developed under two future scenarios of:

- slow uptake of ITS in New Zealand
- rapid uptake of ITS in New Zealand.

Both scenarios have a higher total employment count compared with the baseline, with scenario one just over 2,200 higher and scenario four just over 7,000 higher. Both scenarios have higher employment counts for engineers, ICT and logistics occupation groups, while also having lower counts for drivers, along with repair and maintenance occupations. The latter numbers do not account for the current chronic shortage of automotive technicians and are largely driven down by automotive panel beaters and body builders.

Compared with the baseline projection, which represents the current expected level of future employment, both scenarios show a greater demand for engineers to build and maintain the physical infrastructure of ITS, and ICT professionals to build and maintain the virtual infrastructure and software needed. Compared with the baseline both scenarios show less demand for drivers and for automotive panel beaters and body builders, as ITS requires fewer human drivers and results in fewer crashes requiring repairs.

# Abstract

This paper reports an assessment of skills gaps and training needs likely in 2035 for New Zealand, resulting from the technological change from implementation of intelligent transport systems (ITS) in land transport. The research reported was funded by the New Zealand Transport Agency and conducted in 2017 in Wellington, New Zealand. The economics and engineering literature provides important insights into the impact of technological change on skills demanded and the consequences for occupations and training. Accordingly, to develop the skills gap assessment, we first developed scenarios of future ITS environments in New Zealand in 2035. This was informed by global literature on ITS technologies and their likely implementation by 2035. Paramount among these technologies were autonomous vehicles, where their level of autonomy and coverage of the national vehicle fleet by 2035, is a useful metric of the overall level of ITS development. We present the skills gap assessment in terms of relevant well-defined occupations prevailing in 2017. The occupations considered are: transport, ICT and public policy professionals; automotive technicians and other motor trades workers; and drivers. To indicate the quantum of skills gaps, the paper concludes with empirical projections of numbers of future occupations in demand under an ITS environment.

# 1 Introduction

## 1.1 Background

For the last 120 years the private motor vehicle, powered by the internal combustion engine, has dominated our transportation systems. The new era of intelligent transport systems (ITS), a number of new technologies and the commitment of governments in several countries to an emission-free vehicle fleet by the 2030s is about to trigger a significant step change.

As defined by the US Department of Transportation's (DoT) (2015a) *ITS strategic plan 2015–2019,* ITS infrastructure is a set of tools that facilitates a connected, integrated and automated transportation system that is information intensive to better serve the interests of users and be responsive to the needs of travellers and system operators. ITS technologies improve transportation safety and mobility, reduce environmental impacts, and enhance productivity through the integration of advanced communications-based information and electronic technologies into the transportation infrastructure and vehicles.

From the DoT perspective, ITS products and services can include road weather information, traveller information, adaptive signals, and services such as freeway and highway incident management and road user charges based on actual vehicle use.

While ITS as an emerging area is now reasonably well established, the effect of connected vehicles and technologies towards automation for personal travel and transportation as a service is bringing a new revolution in accessibility, mobility, travel behaviour and travel patterns.

The New Zealand transportation sector needs to get prepared for this change.

This report identifies the technological skill requirements for ITS implementation to 2035. Historic technology cycles have much to tell us about the expected pattern of technology uptake for ITS. In general a characteristic growth path (an S-curve shape) is followed, initially slow and cautious, then rapid and enthusiastic, and then dampened and exhausted.

Continuous improvements in ITS technologies for both infrastructure and vehicles along an overall S-curve will deliver connected mobility outcomes in the long run, desired by society. At each stage along the S-curve, the prevailing level of autonomy of vehicles will be a defining characteristic of both the state of connected mobility and the current level of associated ITS technologies. Along the path to full autonomy and full connected mobility, contributing ITS technologies will gradually improve in multidimensional ways at different speeds on their own S-curves of growth as they are accepted and taken up by society.

ITS is a bundle of technologies and it is reasonable to expect that its overall uptake will follow an S-curve growth path that is an envelope of S-curve growth paths of contributing technologies. Each contributing technology for ITS will be characterised by unique features. Further, demand for these unique features will define demand for new skills.

Consequently, our methodology in this project was to create scenarios for likely envelopes of ITS technologies, each with a different S-curve, to guide us in understanding skills needs and in assessing skills gaps. Our conceptual framework for this research therefore consisted of:

- understanding scenarios for the relevant ITS technological change by 2035 for New Zealand
- assessing the change in skills demanded resulting from scenarios of technological change
- quantifying the change in demand for new workers in skilled occupations to meet this future demand.

To achieve the aim to understand ITS skills gaps in 2035, we have drawn on an evidence base from the economics of technological change (chapter 2), literature guidance on global developments (chapters 3 and 4), expert views of industry stakeholders and academics (chapters 5, 6 and 7), and stakeholder workshops. Guided by this understanding, we have provided a quantitative assessment of future skills gaps with economic modelling (chapter 8). Our summary conclusions (chapter 9) complete this report. Appendices provide technical information and data tables.

## 1.2 Technological change – the internet of things

To help us understand ITS, we must first appreciate the significant influence of the generic technological change that is the internet of things (IoT).

Technological change underpinning development of ITS is one dimension of a wider step change in the role of information and communication technologies (ICTs) in economies and societies globally. This wider step change is the application of the internet to convey data for instantaneous use by people and machinery of all kinds. The OECD (2016) provides a useful definition of IoT as an ecosystem in which applications and services are driven by data collected from devices that sense and interface with the physical world. In the IoT, devices and objects have communication connectivity, either a direct connection to the internet or mediated through local or wide area networks.

Low-cost conveyance and storage of large databases (big data) in universally accessible clouds is a crucial aspect of the IoT. With big data come big data analytics and the IoT is about real time processing of instantaneous data simultaneously from diverse sources. Demand for new innovative services arises because interactions between people and objects are now nested within computer aware environments that can deliver or augment these services through the cloud and supported by powerful analytical tools. The demand for applications (apps) to aggregate, process and communicate useful information from large amounts of data ensures a continued demand from research and innovation to provide the apps. Such apps will be used by devices in homes, public spaces, industry and the natural world. Hence the IoT can be seen as an ecosystem that is an overlapping continuum where it is impossible to isolate the impacts of one technology from the others. In this context ITS is a technology that is interconnected within this continuum and whose deployment and uptake is determined by the IoT.

Four main elements (OECD 2016) can be seen as underpinning the development of the IoT:

- data analytics
- cloud computing
- data communication
- sensors or actuators.

Cloud computing and data analytics include improved machine learning applications, operating at a new level of artificial intelligence. IoT also incorporates the notion of sensing and data analysis driving remote control. For ITS, sensors will:

- sense and analyse current traffic flow
- actuate control responses to adjust traffic stop lights or congestion tolls

- measure and process data from vehicle power trains[1] and then communicate this to other machines for storage and for integration and analysis with other data, potentially from very different types of sensors. Communication can be wired or wireless, short or long range, low or high power, low or high bandwidth.

The automotive industry is already relevant to the emerging IoT. In agriculture, tractors use algorithms to vary the spraying of pesticide and fertiliser; combine harvesters are also able to operate semi-autonomously or work together with a lead-harvester; sensor-equipped machinery can improve processes and convey data in real time to cloud-based internet platforms. The main identified IoT application domains (CERP-IoT 2010) are:

- aerospace and aviation
- automotive
- telecommunications
- intelligent buildings
- medical technology, healthcare
- independent living
- pharmaceutical
- retail, logistics, supply chain management
- manufacturing, product lifecycle management
- oil and gas
- safety, security and privacy
- environment monitoring
- people and goods transportation
- food traceability
- agriculture and breeding
- media, entertainment and ticketing
- insurance
- recycling.

The main IoT enabling technologies (CERP-IoT 2010) are:

- identification technology
- internet of things architecture technology
- communication technology
- network technology
- network discovery

[1] A power train describes the main components that generate power and deliver it to the road surface, water, or air. This includes the engine, transmission, drive shafts, differentials and the final drive (eg drive wheels).

- software and algorithms
- hardware
- data and signal processing technology
- discovery and search engine technologies
- relationship network management technologies
- power and energy storage technologies
- security and privacy technologies
- standardisation.

# 2 Lessons for ITS skills demand from historic technology cycles

## 2.1 Overview

Historic technology cycles have much to tell us about the pattern of technology uptake. In general a similar growth path (an S-curve shape) is followed, initially slow and cautious, then rapid and enthusiastic and then dampened and exhausted. Saturation of the market can be followed by decline in demand as new technologies substitute for existing ones.

This chapter outlines learnings for our study from the behaviour of historic technology cycles. It draws on technology studies and literature on the economies of technological change.

## 2.2 Summary of lessons

This section provides a brief summary of the lessons in this chapter.

### 2.2.1 Lesson 1

ITS technological uptake supported by demand for continuous improvement in connected mobility will follow an S-curve pattern of growth, similar to historic technology cycles.

We expect an S-curve pattern for ITS to align with New Zealand characteristics. In this study, to understand these characteristics we consulted local reports and local stakeholders, including experts from academia, business and policy areas. We assume no decline in the S-curve following saturation, because any such decline is beyond the timeframe for this study.

### 2.2.2 Lesson 2

Rogers (1971) and others explained S-curves as being determined by four main influencers, the innovation itself, communication channels, time and the social system.

In this study, we express these influencers for future ITS for New Zealand in terms of the following seven factors nested within these four main influencers:

1 Innovation

   a autonomy of vehicles

   b power of data analytics

   c technological support of built infrastructure

2 Communication

   a business preference

3 Time

   a period to 2025 and 2035

4 Social system

   a household preference

   b public policy.

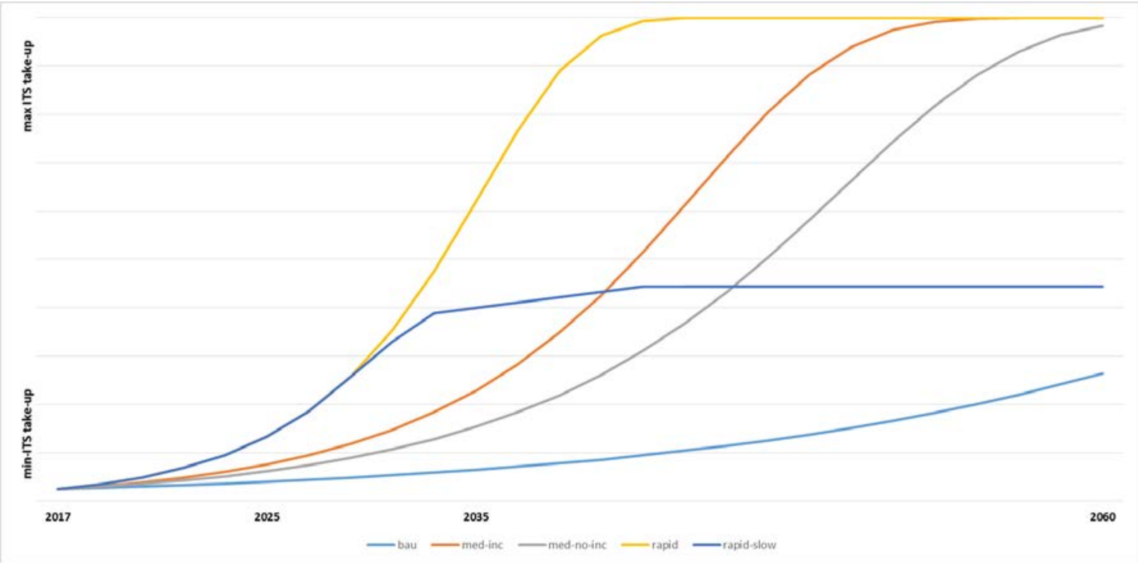
In figure 2.1, we show stylised S-curves for trajectories of five potential ITS scenarios for New Zealand from the present to 2060, 'the very long-term', to illustrate likely outcomes of connected mobility in the long run.

The shape of each S-curve for the respective scenario we have created is explained by the following likely outcomes for long-run connected mobility:

- Slow uptake – no enthusiasm for connected mobility by firms, households and government.
- Medium uptake with no incentives – government agencies are reluctant to invest or subsidise ITS implementation and take-up of technologies, while businesses cautiously invest.
- Medium uptake with incentives – government agencies are willing to support and invest and businesses and households cautiously support.
- Rapid uptake - firms, households and government demand connected mobility, are confident in ITS technology and the technology is available.
- Mixed rapid and slow uptake – firms, households and government are initially enthusiastic about connected mobility, but barriers to uptake of technology emerge and no further uptake ensues.

At 2035, each S-curve is defined by an aggregate of different levels and mixes of technology, determined by the seven factors (above).

**Figure 2.1 Stylised curves for ITS scenarios to 2035 for New Zealand**




## 2.2.3 Lesson 3

The economic literature of Acemoglu and Restrepo (2016) and others tells us that changes in occupation and skills follow technological change. We visualise an occupation as a basket of skills, some or all of which will be affected by technological change.

We investigate and develop a skills gap assessment for the ITS technology change in two extreme scenarios for 2035:

- scenario 1 slow uptake
- scenario 4 rapid uptake.

### 2.2.4 Lesson 4

Selected economics literature tells us that changes in qualifications supplied by the labour force follow changes in skills demanded by firms through adjustments in relative wages.

We investigate and develop a qualification needs assessment based on the skills gap assessment. International literature and New Zealand perspectives guide this.

### 2.2.5 Lesson 5

Empirical projections provide insights for policy guidance.

We quantify the skills gaps and training needs assessment to 2035 with projections of future labour demand. These are based on projected economic growth for the whole economy, adjusted for estimated changes in growth of relevant occupations due to ITS implementation.

## 2.3 Lesson 1 – the S-curve

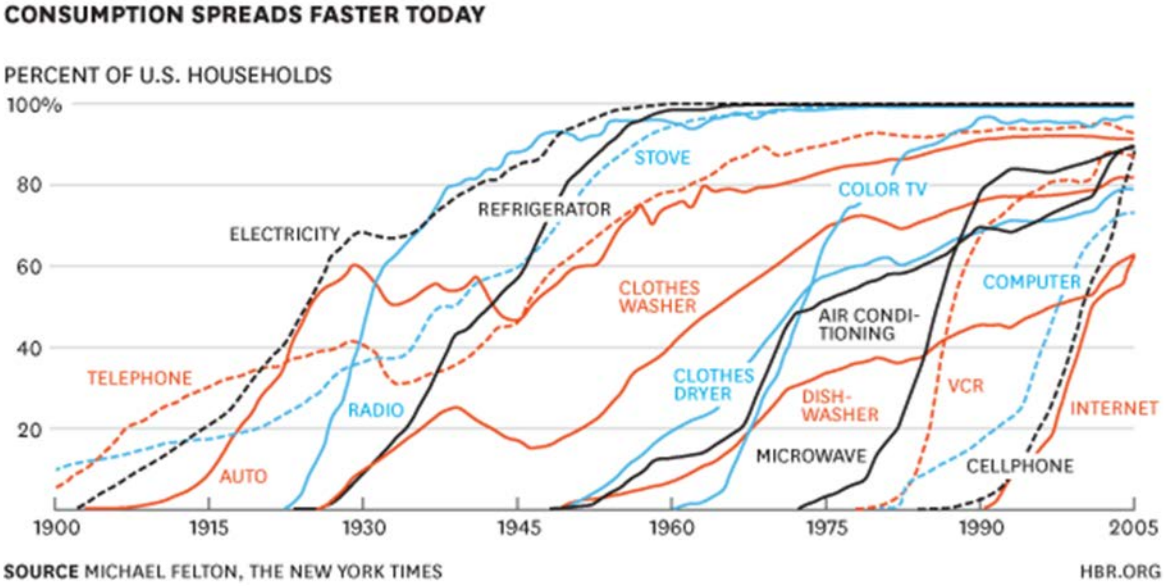
The adoption of ITS and therefore its impact on skills demand is likely to follow the characteristic adoption profile of all technologies, called the 'S-curve'. New technologies are initially adopted by people familiar with their technical attributes or attracted by their novelty, with high launch prices having a demonstration effect in the market, which gives early adopters high utility. This is followed by rapid uptake by the wider population as their acceptance grows and the cost of the technology falls through economies of scale in production and with the expiry of patents. Eventually the market is near-saturated and the growth rate of further demand is low, or turns negative. McGrath (2015) suggests this technology cycle occurs faster for recent technologies than for previous ones and cites figure 2.2 (below) to illustrate this. For example, it took decades for 50% of US households to have the telephone, but only five years for cellphones.

Morgan Stanley (2015) observes that the IoT technology cycle is just commencing. That is, the cycle is at the low growth initial phase, where early adopters are people who understand the technology, such as engineers. In a future and rapid adoption phase, the fully autonomous vehicle (AV) will be in widespread use. Through the IoT AVs will communicate with other devices, including road infrastructure, global positioning systems (GPS), sensors, safety infrastructure, smart phones and other vehicles.

There are many historic technology cycles that may provide insights into the likely adoption pattern of ITS and potential impacts for skills demand in ITS-related industries. Here we briefly consider the smartphone as one example.

The smartphone (mobile internet) technology cycle required built infrastructure in the form of ubiquitous wireless connectivity. Protocols for fast and reliable, yet expensive data transfer led early adopters to use smartphones for business. Reduced costs for data transfer and the availability of customised applications (apps) for social media and other purposes led to rapid use by the public generally.

**Figure 2.2 S-curves for historic technology cycles**




The AV technology is a new technology and while it may exhibit the same S shaped adoption curve as the traditional auto industry, its application may be as different as the difference between the smartphone (requiring a high degree of non-appropriable technology) and the dial-up telephone (requiring a much lesser degree). Indeed, the remarkable potential for AVs to create demand for new goods and services arises from its position within the wider technology cycle of the IoT, rather than its origins within the traditional auto industry.

## 2.4 Lesson 2 – the composition of the S-curve

The technology adoption cycle has been described as a social diffusion process and articulated by Rogers (1971) and others. The four main parts of this diffusion process are: (i) the innovation itself; (ii) communication channels; (iii) time; and (iv) a social system. Consequently, different societies will adopt the same technology differently, partly because of their social preferences and partly because of their capacity to utilise the new technology. Innovators in different societies will also find different opportunities to develop new products and adapt existing ones, within the same technology product development cycle.

Morgan Stanley (2015) discusses this potential for new opportunities in the context of ITS. The paper says the utility of the vehicle is much less concerned with the components of the automotive technology cycle that are the power train, frame and body. It is more concerned with the components of the IoT technology cycle that are interactions with other devices and sensors in the environment, and human-centric interactions with people. Unlike the traditional auto industry, the S-curve for ITS will be influenced by ubiquitous standardised technologies, shared software, and shared big data storage and analysis. Consequently, in this scenario, the auto industry in an ITS environment may become, in part, an open source industry. This is somewhat analogous to the smartphone industry supplying the hardware, adhering to common protocols and standards, while enabling new industries to expand, such as for social media, entertainment, information, car rental, healthcare and social services delivery.

Compared with the ITS auto industry, the traditional auto industry protects its technologies and production techniques. Original equipment manufacturers are generally vertically integrated to the extent that they design and build their own unique power train, frame and body. Hence, implementation of ITS represents a paradigm shift for auto makers and create opportunities for other industries, including local ones in the case of New Zealand.

## 2.5 Lesson 3 – a change in skills follows a technological change

As noted under 2.2, the economic literature of Acemoglu and Restrepo (2016) and others tells us that changes in occupation and skills follow technological change. We visualise an occupation as a basket of skills, some or all of which will be affected by technological change.

Acemoglu and Restrepo say that while technological change does eliminate the need for some skills, it creates the need for new ones, which are usually more complex. In their view, provided this rate of growth for new skills balances the reduced demand for skills replaced by automation, there is no major aggregate labour demand decline. In this view skills change happens as a consequence of technology change.

> *Many economists throughout history have been proven wrong in predicting that technological progress will cause irreversible damage to the labour market…the labour market has always adapted to the replacement of jobs with capital, ….. As long as the rate of automation of jobs by machines and the creation of new complex tasks for workers are balanced, there will be no major labour market decline. The nature of new technology, and its impact on future innovation potential, has important implications for labour stability.* (Acemoglu and Restrepo 2016)

One objective of this report is assessing the likely skills change following the implementation of ITS. The direction of causation (technological change causes skills changes) articulated by Acemoglu and Restrepo suggests we should first assess the nature and scope of technological change and then subsequently assess the resulting skills changes.

Acemoglu and Restrepo (2016) explain that technological change creates two opposing forces which, when balanced, result in an equilibrium between demand for and supply of skills. One force is driving automation to replace existing tasks and another force is creating new complex tasks to support the new technology. The balancing occurs when the relative price of new technological capital and the relative price of skilled labour reach a new equilibrium. We note that this model is simplistic in the sense that it treats all labour as homogeneous. In practice, automation is likely to reduce the demand for labour using codified knowledge, but increase the demand for labour using tacit knowledge.

> *The rates at which automation and the creation of new complex tasks proceed is endogenised, and responds to whichever of these two activities are more profitable. For example, the cheaper capital is, the more profitable automation is, which replaces the relatively expensive labour with cheaper capital. In the endogenous technology version of the model, this greater profitability triggers further automation. This conceptual structure is useful for two related reasons. First, it helps us identify the forces that act as stabilisers — so that once automation pulls ahead of the creation of new labour-intensive tasks, there will be economic forces that induce a faster creation of new tasks as well. Second, it helps us delineate conditions under which the torrent of new automation technologies that we are currently witnessing will not self-correct and will thus have long-term adverse consequences for the prospects of labour.*
>
> *The stabilising forces in the model stem from 'price effects'. Because automation tends to reduce payments to labour, it also increases the profitability of the creation of new complex*

> *tasks relative to further automation. This stabilising force implies that rapid automation tends to self-correct itself, provided that it takes place within an environment in which the technology for creating future innovations and R&D of different types remains unchanged.*
>
> *Under these circumstances, the economy will ultimately return back to its state before the arrival of these automation technologies. If so, the current difficulties of workers in the face of new technologies notwithstanding, the future may not be bleak for labour.* (Acemoglu and Restrepo 2016)

Acemoglu and Restrepo (2016) caution, however, that if the technological change is so fundamental as to completely eliminate the potential for creation of new skills, then overall demand for labour will decline.

> *Nevertheless, this stabilising force does not imply that all sorts of changes will necessarily reverse themselves. If what has changed is the technology for creating future innovations, and in particular, if automation-related innovations have become easier than creating new tasks, then the wave of new automation technologies we are now seeing will be just the first stage before the economy settles into a new long-run equilibrium with worse prospects for labour. Overall, the extent to which the future will validate concerns about rising technological non-employment will depend on whether we are witnessing a period of rapid discovery of new automation technologies or a fundamental shift in how we are able to produce technologies for the future.* (Acemoglu and Restrepo 2016)

Empirical evidence supportive of a positive impact of technological change for skills demand is found in the work of Moretti (2012). This study found that for each job created in the software, technology and life-sciences industries in the US from 2000 to 2010, five new jobs were indirectly created in the local economy, two in high-skill occupations (eg doctors and lawyers) and three in low-skill occupations (eg waiters, barbers and store clerks). Arguably the level of causality is not as high as a five-fold increase, because the overall increase includes overall employment growth.

A contrasting projection is presented by the work of Frey and Osborne (2013) who predict that roughly half the broadly defined occupations are at risk of automation over the next decades, independently on their skill content. According to the authors, the only jobs that will remain in the human domain (but not forever) are those characterised by creativity and other intrinsic attributes of humans that give them a comparative advantage over machines. Quite apart from the pessimistic perspective, an important message from Frey and Osborne is that consumer preferences for human-centric services will endure and increase following technological change.

An important theme for future labour demand arising from ITS implementation is the significant potential for human-centric services. This continued demand for human-centric services, often routine and low skilled is indicated by the findings of Autor and Dorn (2013) who look at the change in US employment by skill percentile, as measured by wages, over the period 1980–2005. They observe an increase of employment not only in high-skill occupations but also in the low-skill ones. In contrast, employment stagnated or even decreased in middle-skill occupations. Autor and Dorn (2013) argue that real wages by skill percentile follow a similar path, suggesting that the increase in employment at the two tails of the skill distribution, for high and low skills, was driven by an increase in demand rather than supply.

Acemoglu and Autor (2010) also suggest that low-skilled workers benefit, in the long term from technological change. This arises because opportunities for low-skilled workers increase from skills becoming standardised. For example, use of the internet quickly became ubiquitous and easy for many workers, including low-skilled workers:

> *When different workers have different amounts of skills, both automation and the creation of new tasks may lead to greater inequality – in the first case, because machines compete more strongly against less skilled labour; and in the second, because the more skilled workers have greater competitive advantage than the less skilled in new complex tasks. However, we show that as long as over time, tasks become standardised and are more easily performed by less skilled labour, the introduction of new complex tasks benefits those workers as well as the more skilled ones. Depending on how rapidly this standardisation process takes place, the economy might generate powerful forces self-correcting the inequality implications of automation technologies as well.* (Acemoglu and Autor 2010)

Acemoglu and Autor (2010) dismiss the pessimistic view that new digital technologies, artificial intelligence and robotics will create widespread technological non-employment. They say that a major shortcoming of the typical arguments about technological non-employment is that there is no clear reason why the effect of new technologies will be different this time than in the past, when they did not create such widespread reductions in employment.

When the change in skills demanded of an occupation is large, the occupation itself changes and new occupations emerge. This is consistent with Acemoglu and Autor (2010) findings.

> *The importance of new complex tasks can also be seen in recent US labour market dynamics. Employment figures document not just the automation of existing labour-intensive jobs, but also the rise of new occupations, ranging from engineering and programming jobs to those performed by audio-visual specialists, executive assistants, data administrators and analysts, meeting planners, or computer support specialists. Indeed, during the last 30 years, new tasks and new job titles account for a large fraction of US employment growth.*

Acemoglu and Autor (2010) use data from a study by Lin (2011) that measures the share of new job titles, in which workers perform newer tasks than those employed in more traditional jobs, within each occupation. In 2000, about 70% of the workers employed as computer software developers (an occupation employing one million people at the time) held new job titles.

In section 3.1 below, we present scenarios of ITS implementation that consist of a combination of factors. It is important to note some of these (eg household preferences for ITS) can constrain the pace of take-up of ITS. This will constrain the impact of technological change on skills change. Acemoglu and Autor (2010) note the need to consider such constraints:

> *….since there may be major differences in the ability of technology to automate and also to create new tasks across industries (eg Polanyi 1966, Autor et al 2003), the extent to which these differences become constraining factors needs to be investigated*

They also underscore the importance of empirical work such as this present study to assess the impact of technological change on skills demand:

> *Finally, and most importantly, there is great need for empirical evidence on the impact of automation and robotics on employment. Indeed, whether rapid automation does act as an impetus for the creation of new complex tasks is of the utmost importance to provide greater empirical content to the framework developed here.*

Our visualisation of an occupation as a basket of skills, expresses the continued demand for most occupations, despite the skills changes within them. This is because, while technological change may reduce the need for some skills of an occupation, it will not change the demand for others. Further, it may create a new demand for new skills within that occupation. This visualisation is a generalisation, since in practice, some occupations do vanish over time and there are many job title changes.

In the context of ITS implementation, we can consider the future demand for human drivers of vehicles. Human drivers utilise a number of skills, only one of which is the control and operation of the vehicle. If AVs were successful, then autonomous taxis, buses and trucks would lead to lower demand for their control and operation skills. It is likely that fully AVs are some way into the future. In the interim, the technology cycle for ITS is expected to evolve from driver controlled vehicles to semi-autonomous vehicles. In the absence of fully AVs, the number of drivers required is unknown. This is because some human control is required for semi-autonomous vehicles. Even if the number of drivers per fleet decline, the demand for fleets may increase due to the lower cost to customers in a competitive environment.

Despite a likely decline in demand for control and operation skills, there will probably be a continued need for some time yet for human drivers to provide mobility services. Litman (2017) provides an analogy from trends in automated banking services:

> *Personal computers first became available for purchase during the 1970s, the Internet became public during the 1980s, automated teller machines (ATMs) became common in the 1990s, most households were using the Internet for personal business activities by the 2000s, and for decades banks have encouraged customers to use central call centers rather than local offices to answer questions, yet these technologies have not eliminated the need for local banks with human tellers.*
>
> *Automated banking can reduce the number of branch offices and employees, but customers often need to interact with human tellers due to personal preferences, and because it is often faster and less frustrating, and therefore more productive, than automated, Internet or telephone options. Automation has had evolutionary rather than revolutionary impacts on bank activities. Other trends, such as new banking services, changing regulations and new management practices, have equal or greater impacts on bank infrastructure planning.*

Litman's example is illustrative in that it makes the case for continuance of human-centric occupations that provide personal services, in the face of automation. The overall labour-reducing impact of automation is clearly shown by census data. For clerical and sales workers, employment fell 5% from 2006 to 2013 in New Zealand.

Litman suggests that autonomous vehicle implementation will probably follow similar patterns in that deployment:

- will be evolutionary and likely to take several decades
- is unlikely to totally displace current technology
- will have costs as well as benefits
- will only marginally affect infrastructure planning for the foreseeable future.

Litman's view is that autonomous vehicle implementation is one of several current trends likely to affect road, parking and public transport demands, and these changes will probably occur gradually over several decades.

The OECD (2016) expects automation, through the development of the IoT, to create demand for new human-centric skills. It is widely believed by Morgan Stanley (2015) and others that ITS implementation will produce a similar demand. The internet transformed the skill sets required in the media industry. Media agencies developed digital expertise in-house to cover customer relationship via the web. Social media and new digital agencies also provided skilled workers for such services. There was a transformation in the skills required to fill these new professional profiles (graphic designers, web developers, social media agents, community managers and so forth), with a greater opportunity for jobs requiring creativity and more intellectually challenging tasks.

## 2.6 Lesson 4 – a change in qualifications follows a change in skills

The IoT brings a skills opportunity in several areas such as data curation, open data, big data analytics and cloud computing processing. The OECD (2016) suggests that for each of these areas, there is a need to identify the skills required by the future workforce, align the curricula to support the development of the skills and promote training opportunities through a combination of formal and informal methods. Similarly, there is a need for an assessment of skills required for ITS implementation, together with the development of training opportunities.

In order to meet future skills needs under the IoT, the OECD (2016) sees a need for governments and policy makers to understand how to adapt their education systems so that alignment with industry improves. It suggests that training programmes covering both generic and technical skills should adjust displaced workers ensuring that the supply of new skills keeps pace with the new demands in the IoT-related sector such as sensors, robotics, data analytics and software development. This observation about training needs is directly relevant to the implementation of ITS.

Under technological change, new technologies can substitute for non-cognitive manual tasks. Importantly, the impact for qualifications based around specific cognitive tasks is that these tasks can also substitute for other cognitive tasks. As an example, Autor et al (2003) argue that this happens for computer technologies when the specific tasks are defined by explicit rules that can be addressed by qualifications relevant to other tasks. At the same time, Autor et al say that computer technologies complement workers in performing non-routine problem solving and complex communications.

Autor et al’s (2003) empirical work, using representative data on task input for 1960 to 1998 in the US, finds that within industries, occupations and education groups, computerisation is associated with reduced labour input of routine manual and routine cognitive tasks and increased labour input of non-routine cognitive tasks. As the price of computer technologies declined, Autor et al posit that industries and occupations reduced labour input into routine tasks, for which computer capital substitutes, and increased demand for non-routine task input, which computer capital complements.

The impact for qualifications is that, overall, there was an increase in relative demand for highly educated workers, who held comparative advantage in non-routine versus routine tasks. Simply put, changes in qualifications were consequent upon a change in skills brought about by technological change.

Accordingly, in this study, we followed a chronological sequence, where we:

- developed scenarios of ITS technological change for 2035 in New Zealand
- assessed skills gaps likely to arise in 2035 based on current expectations and trajectories of skills supply and expected future demand
- reflected on the qualification and training needs to provide the required new skills.

The technological change described by Autor et al (2003) was brought about by the declining price of computer technologies relative to labour input.

> *Computer technology substitutes for workers in performing routine tasks that can be readily described with programmed rules, while complementing workers in executing non-routine*

*tasks demanding flexibility, creativity, generalized problem-solving capabilities, and complex communications.*

*As the price of computer capital fell precipitously in recent decades, these two mechanisms—substitution and complementarity—have raised relative demand for workers who hold a comparative advantage in non-routine tasks, typically college-educated workers. Our task framework emphasizes that the causal force by which advancing computer technology affects skill demand is the declining price of computer capital—an economy-wide phenomenon.*

Autor et al (2003) established that:

*...industries undergoing rapid computerization reduced labor input of routine cognitive and manual tasks and increased labor input of non-routine interactive and analytic tasks. Since better educated workers are likely to hold a comparative advantage in non-routine versus routine tasks, one interpretation of these results is that they confirm the established pattern of increasing relative educational intensity in computerizing industries over the past several decades.*

Overall Autor et al (2003) conclude that the empirical results support (with some caveats) the view that technological change had a significant influence on raising the demand for higher qualifications:

*...these findings demonstrate that shifts in job content away from routine tasks and toward non-routine cognitive tasks are a pervasive feature of the data and are concentrated in industries and occupations that adopted computer technology most rapidly.....*

*....these illustrative calculations demonstrate that changes in task demands accompanying workplace computerization are economically large and—with caveats noted—could have contributed substantially to relative demand shifts favoring educated labor in the United States since 1970.*

## 2.7 Lesson 5 – empirical projections provide insights

This report presents empirical projections to quantify, by way of an order of magnitude, the future demand for occupations and qualifications indicated by the qualitative skills gap assessment and assessment of qualification needs. Projections to 2035 are developed. A baseline projection for growth in demand for skills characterised by a non-ITS environment is developed using conventional macroeconomic modelling. This is done for 55 occupations relevant to ITS implementation. The trajectories for these are then adjusted in a transparent way to account for expected increases and decreases due to ITS implementation in two of the five scenarios. These adjustments are informed by published studies of expected global trends and validated for New Zealand with stakeholder and expert views.

The principle underpinning this type of empirical work is strongly endorsed by Acemoglu and Restrepo (2016):

*....most importantly, there is great need for empirical evidence on the impact of automation and robotics on employment. Indeed, whether rapid automation does act as an impetus for the creation of new complex tasks is of the utmost importance to provide greater empirical content to the framework developed here.*

# 3 Global future ITS technologies

## 3.1 Introduction

As noted in the previous chapter, we can think of S-curves as describing either:

- the pathway for growth and implementation of one technology, assuming it prevails in the long term and is not superseded by a newer one
- an envelope of many S-curves for many technologies that together constitute the overall state of ITS.

ITS is composed of a number of constituent technologies. Changes in the take up of these technologies will influence overall skills demand associated with them individually and together.

In this chapter we present an outline of expectations from selected reports for future ITS technologies globally. This outline provides a context for:

- a discussion of global skills gap assessments in chapter 4
- a discussion of ITS technologies for New Zealand, in chapter 5.

In chapter 6 we present our own skills gap assessment for New Zealand and in chapter 8 we quantify and report on projected demand in 2030, for certain occupations and occupation groups, resulting from ITS implementation. Chapter 7 provides an assessment of the consequential training needs.

This chapter has two main parts: one concerns ITS technologies associated with infrastructure while the other concerns those associated with vehicles.

## 3.2 ITS technologies

### 3.2.1 Definition of ITS infrastructure technologies

The US Department of Transportation (DoT) has been developing its ITS programme in the US for over 25 years. In that time ITS has used modern computers and communications to make travel smarter, reliable, safer and more convenient. In general for the DoT, ITS applies high technology (sensors) and computer power to current highway, traffic and public transport (transit) systems. These systems have the potential to solve future problems of increases in population, traffic congestion and less land for new roads.

As a guide to the role of ITS in enhancing transportation, the DoT lists the following major ways in which ITS enhances transportation:

- Intelligent traffic control systems help by reducing the time we spend stopped at traffic signals or waiting on motorways when a crash occurs.
- Automatic toll collection moves vehicles more quickly through toll booths, reducing congestion and pollution.
- Traveller information systems provide current, multi-modal information on travel conditions allowing travellers to make smarter choices about how, when and where to travel.
- In-vehicle systems help by providing in-vehicle maps and improving safety by automatically notifying emergency services when a serious crash occurs and exactly where the crash is located.
- Advanced public transport systems help agencies operate more efficiently and provide travellers with real-time information that makes using public transport easier and more attractive.

- Intelligent commercial vehicle systems help commercial vehicle operators process the paperwork associated with moving goods. These systems also help public agencies improve safety by inspecting the vehicles that need it the most.

### 3.2.2 Definition of ITS vehicle technologies

Connected vehicles (CVs) include autonomous vehicles AVs and represent the development and deployment of a fully connected transportation system that makes the most of multi-modal, transformational applications that require a robust, underlying ITS infrastructure platform.

CVs consist of vehicles or mobile devices equipped with sensors, communications and processing allowing location and situational status to be communicated among the vehicles and with the surrounding infrastructure. The CV platform needs to be flexible and allow for growth, expandability and incorporation of newly evolving technologies. In knowing the architectural configuration and definition of interfaces, creative private sector firms will be able to develop new applications that are not yet envisioned but remain in the future. Importantly, the CV platform will be based on the complexity and range of human behaviours that will interact with and impact upon the system.

### 3.2.3 The CVRIA framework for ITS technologies – infrastructure and vehicle

Globally, nations are developing frameworks to define and describe ITS relevant technologies and the relevant skills required to implement them.

These include the Connected Vehicle Reference Implementation Architecture (CVRIA), reported by the US Department of Transport (2016). These CVRIA standards and recommendations provide a framework to assess the implementation of ITS.

The main impact of the CVRIA was the standardisation of the wireless communication standard. 5.9GHz DSRC with IEE 802.11p is now the standard for communication in most areas. Japan has maintained its standard of 5.8 GHz DSRC.

CVRIA classifies connected vehicle applications in four types: environmental, mobility, safety and support that span all technologies for ITS implementation.

### 3.2.4 Main technologies – infrastructure and vehicle

Using the CVRIA framework, Ezell (2010) describes typical underlying technologies for ITS:

- autonomous vehicles
- big data
- radio frequency identification technology (RFID)
- geographic information systems (GIS)
- global positioning system (GPS)
- dedicated-short range communications (DSRC)
- vehicle to vehicle (V2V)
- vehicle to infrastructure – (V2I)
- decision support systems
- traffic analysis and modelling

- variable message signs (VMS)
- road weather information systems (RWIS)
- database management systems
- data mining
- security and access management
- parking management systems
- mobility as a service (MaaS).

#### 3.2.4.1 Autonomous vehicles

The AV literature is vast and we do not propose to outline the technologies required for manufacture because these technologies will have much less relevance for future skills demand in New Zealand than other ITS technologies. However, telematics embedded in vehicles will have important implications for future skills demanded and these are discussed next.

#### 3.2.4.2 Embedded telematics in vehicles

Vehicles can be connected to other devices and infrastructure through a cellular network. This can occur where the driver uses a nomadic device such as a smartphone: (i) as a modem to tether the vehicle or (ii) to access apps present in the vehicle. Embedded telematics, where a SIM card and communication module are embedded in the vehicle itself, provide a more advanced form of connectivity. There will be a demand for provision of: (i) improved devices and services; (ii) access to them through cellular networks of network providers; and (iii) cloud-based solutions rather than reliance on apps in devices.

#### 3.2.4.3 Big data

The big data concept is fundamental to ITS. The ability to collect, analyse and disseminate information in real time to roadside equipment or messaging units or communication devices is a critical success factor enabling AVs.

Data collection involves collection of information from vehicle dynamics, road weather systems, braking, acceleration, incidents, GPS and scanning location-based information from social applications (Facebook, Linkedin) and Bluetooth. The data from each vehicle and pedestrian in the eco-system is collected, analysed and appropriate messages will be relayed back to V2I systems in necessary fashion to fully automate trips and enable smart city. As noted by Weishan Dong (2016):

> *Learning from telematics or connected vehicle data is a key technology of Big Data analytics in intelligent transport systems. How to aggregate the continuous big data inputs collected by moving vehicles and generate insights, e.g., automatic detection of map updates, is not only an important research problem, but also a hot topic with significant market values and impacts*

The analysis of data involves manipulating large amounts of data (data mining) and representing the data in a manner that can be supplied to vehicles or other messaging terminals (like personal devices), which enables the end user (or equipment) to automate the action. These actions can include re-routing, reduce speed warning, dynamic lane restrictions, dynamic scheduling of public transport systems. Over the learning curve, big data will enable automatic decision support systems by utilising artificial intelligence and increased accuracy with more data collected from the transport eco-system.

#### 3.2.4.4 Radio frequency identification technology (RFID)

RFID is used to streamline vehicle production, improve logistics, increase quality control and improve customer service. The devices attached to parts contain information related to the name of the manufacturer and when and where the product was made, its serial number, type, product code and in some applications the precise location in the facility at that moment. RFID technology provides real-time data in the manufacturing process, maintenance operations and offers a new way of managing recalls more effectively. The use of wireless identifiable devices helps the stakeholders to gain insight into where everything is so it is possible to accelerate assembly processes and locate cars or components in a fraction of the time.

#### 3.2.4.5 Geographic information systems (GIS)

GIS are important technologies that are critical for AVs. GIS involve the accurate mapping of the geographic area (roads, terrains, landmarks etc) and identifying objects in the vehicle path correctly for navigation. GIS will also involve accurately rating the roads for loads enabling dedicated freight ways. GIS coupled together with GPS and real time traffic data will control the future of transportation. GIS coupled with GPS will also enable congestion pricing or similar congestion control measures and road user charges based on actual road use that can be deployed for driver-controlled and autonomous driving.

#### 3.2.4.6 Global positioning system (GPS)

Embedded GPS receivers in on-board units of vehicles receive signals from several different satellites to calculate the vehicle's position. This requires line of sight to satellites, which can inhibit use of GPS in some settings due to "urban canyon" effects. GPS is the core technology behind many in-vehicle navigation and route guidance systems. On-board units equipped with satellite-based GPS devices can record distance travelled to estimate road user charges.

GPS technology has matured from its inception in 1970s by the US military. It has extended to many regional systems covering accurate positioning worldwide. Redundant positioning satellites offer more accuracy than ever before. The advancement in this technology to accurately position and locate any object within an accuracy of centimetres is very critical in the AV world. The development of GPS systems involves satellites and ground positioning for shorter accurate range of positioning.

Automotive navigation systems use satellite navigation systems (which rely on GPS technology) to provide the positioning details. Automotive navigation systems have come a long way from their inception in 1966, and now incorporate drivetrain, gyroscopes and accelerometers to overcome short-range signal loss in urban canyons and tunnels, thereby increasing reliability and accuracy.

#### 3.2.4.7 Dedicated short range communications (DSRC)

DSRC are available in a short- to medium-range wireless communication channel, in the 5.8 or 5.9 GHz wireless spectrum, specifically designed for automotive uses. Critically, DSRC enable two-way wireless communications between the vehicle (through embedded tags or sensors) and roadside equipment. DSRC are a key enabling technology for many ITS technologies, including V2I integration, V2V communication, adaptive traffic signal timing, electronic toll collection, congestion charging, electronic road pricing and information provision The technology for ITS applications is internationally incompatible and works on the 5.9GHz band (US) or the 5.8GHz band (Japan and Europe). Currently, the US Federal Communications Commission has allocated 75 MHz and the European Telecommunications Standards Institute 30 MHz of spectrum in the 5.9 GHz band for the operation of ITS services.

#### 3.2.4.8 Vehicle to vehicle (V2V)

V2V communications enable short-range messaging via DSRC. This provides for rapid decelerations, air bag deployments, adaptive cruise controls and intermediate routes to enable platooning (see chapter 3), as well as many other functions.

#### 3.2.4.9 Vehicle to infrastructure (V2I)

V2I communication systems provide vehicles with critical information along the infrastructure path including on hidden queues, at crashes, on slippery road surfaces and cautionary advice. V2I also collects data from vehicles for real-time processing to decide on the active messages to be passed to the AV or the driver on their nomadic devices. This active processing and decision making are automated using decision support systems. Active messages will include message packets to reduce speed, change state of light beams, change route, or brake.

#### 3.2.4.10 Decision support systems

Decision support systems are automated systems that take in known inputs, process the information in real time and send out calibrated outputs enabling real-time decisions to perform critical actions. For ITS decision support systems play critical part by taking in big data from various vehicles in the ecosystem, processing them and sending out messages to take necessary actions, such as re-routing. These may include re-routing functionality, dynamically changing lane controls, etc.

#### 3.2.4.11 Traffic analysis and modelling

Traffic analysis and modelling is an important aspect of transportation and in turn ITS. Simulations and modelling are becoming very important and critical in predicting and analysing traffic behaviours. Some of the newer control systems are simulated and modelled to create a certainty while being implemented and to avoid unexpected surprises.

#### 3.2.4.12 Variable message signs (VMS)

VMS connected vehicle data and disseminate results to drivers and connected vehicles such as messages for change of speed, dynamic bus lane priority, eco lanes etc.

On-board dynamic display systems are also going to be part of VMS in future. Each system functions as a medium to disseminate processed information to drivers to enable informed decisions along their journey. These units may further advance these messages to data packets for passing information directly to vehicle control systems.

#### 3.2.4.13 Road weather information systems (RWIS)

Road weather information systems typically comprise mini weather stations that are spread across a wide area in the road ecosystem. These systems collect and transmit spot weather information to enable safer driving. RWIS also upload details to big data ecosystems and decision support systems to enable a wider dissemination of calculated weather predictions to enable safer pathways for connected vehicles.

#### 3.2.4.14 Database management systems (DMBS)

Large-scale DMBS with data spread and residing in the cloud will analyse large amounts of data for ITS. Each vehicle and IoT enabled device will upload information from each vehicle triggering a huge data flow across 3G or 4G or Wifi networks. Roadside units will also be uploading information to these systems.

#### 3.2.4.15 Data mining

The process of extracting relevant information packets from a huge amount of raw data in the DBMS either by searching, sorting or doing meaningful transformations is called data mining. Data mining will become increasingly relevant as connected vehicle units send more and more real-time data into the big data ecosystem.

#### 3.2.4.16 Security and access management

The large influx of data collected from individual vehicles will require storage. A large amount of digital storage warrants security and access management to this data so the privacy of individuals is kept intact. Large-scale encryption and encrypted data transfer systems will be necessary to address privacy issues arising from the huge amount of data being collected from individuals or vehicles owned by individuals. These systems should also be capable of anonymising information before presenting it in digital format to vehicle units or nomadic devices.

#### 3.2.4.17 Parking management systems

Automated and connected parking management systems are critical for ITS. Parking management systems make reservations and de-allocations in real time. Parking management systems will also be automated for revenue collection and fines.

#### 3.2.4.18 Mobility as a service-(MaaS)

One important area that comprises multiple ITS technologies is providing MaaS. This describes a well-organised transport ecosystem where transport is considered as a service offered by a higher-level organisation (such as a local council or commercial vehicle fleet business) rather than a functional single user entity. MaaS includes commercial vehicle fleets providing mobility between endpoints; ride-sharing services integrating over various modes, payments systems, efficient transfers across modes, and efficient trip and route planning.

## 3.3 ITS technologies – coverage

In the future, the coverage and complexity of ITS technologies, both infrastructure and vehicle, over the transport network will likely match the take-up of autonomous vehicles and their level of autonomy. For example, we would expect to see provision of dedicated lanes for semi-autonomous buses when semi-autonomous buses are available and accepted by the community. This is more likely to happen in some geographic areas or on some types of roads than others. Full autonomy requires a large step change in both infrastructure and vehicle technology. Prior to that taking place, we are likely to experience an environment of connected mobility that develops in a multidimensional way in specific circumstances and locations, as various contributing technologies are made available and are individually accepted and taken up by society.

In this study, we assume that the scale and complexity of ITS implementation is measured to a reasonable approximation by the scale and complexity of autonomous vehicles. This approach is justified by the view that the autonomous vehicle is the *sine qua non* of ITS technologies. It is the smallest critical component of the set of all ITS technologies, such as defined by the CVRIA framework (above). This section helps us understand the levels of vehicle autonomy. This understanding is necessary if we are to use this as a metric of ITS implementation, together with assessments of their penetration into the national vehicle fleets, globally.

### 3.3.1 Levels of automation

The level of autonomy is an important determinant of take-up of autonomous vehicles. The Society of Automotive Engineers (SAE) (2016) has defined different levels of automated functionality, ranging from no AV features (level 0) to full automation (level 5).

One of the major distinctions drawn is between levels 0–2 and 3–5, based on whether the human operator or automated system is primarily responsible for monitoring the driving environment. The definitions categorise vehicles into levels of increasing automation, outlined below:

- Level 0: No automation
- Level 1: Automation of one primary control function, eg adaptive cruise control, self-parking, lane-keep assist or autonomous braking
- Level 2: Automation of two or more primary control functions 'designed to work in unison to relieve the driver of control of those functions'
- Level 3: Limited self-driving; driver may 'cede full control of all safety critical functions under certain traffic or environmental conditions', but it is 'expected to be available for occasional control' with adequate warning
- Level 4: Full self-driving without human controls within a well-defined operational design domain, with operations capability even if a human driver does not respond appropriately to a request to intervene
- Level 5: Full self-driving without human controls in all driving environments that can be managed by a human driver.

### 3.3.2 Timing of global penetration of autonomous vehicles

Estimates of the timing of global penetration of AVs into national vehicle fleets are helpful guides to understand the future timing of ITS implementation. Such timing on a global scale will also guide our estimation of timing for New Zealand. While there are a number of views on this level of penetration, there is a wide consensus that such penetration will occur gradually and over limited levels of autonomy by 2025 and 2035.

Litman (2017) estimates that deployment could likely follow the pattern of automatic transmissions, which could take nearly five decades to reach market saturation, while a portion of motorists continue to choose manual transmissions due to personal preferences and cost savings in some cases.

Litman (2017) summarises projected AV implementation rates based on previous vehicle technology deployment. This view suggests that:

- in the 2030s, AVs, available with moderate price premium, will comprise about 10% to 20% of the vehicle fleet
- fully AV implementation will probably take several decades.

Our skills gap assessment in chapter 6 and our empirical projections of future demand for occupations and qualifications in chapter 8, both assume the percentage of the New Zealand national vehicle fleet that is highly autonomous (in some cases fully autonomous) will be within this range of 10% to 20%.

Morgan Stanley (2015) suggests four phase of autonomous vehicle adoption.

- Phase 1 – Passive autonomous driving (0–3 years), where autonomous capability is not meant to control the car but only acts as a second line of defence in the event that a mistake by the driver is about to cause a crash.
- Phase 2 – Limited driver substitution (3–5 years), where the driver is still the primary operator of the vehicle under all conditions though they can give up some duties to the vehicle.
- Phase 3 – Complete autonomous capability (5–10 years), where the car can accelerate, brake and steer by itself in mixed and transitional driving conditions but the driver should remain in the driver's seat ready to take over in the event of an emergency or system failure.

- Phase 4 – 100% penetration (two decades), where all cars on the road have at least a phase 3 level of autonomous capability and full V2V/V2X capability, and the cars are capable of driving themselves with zero human intervention.

Morgan Stanley's (2015) view is that achievement of phase 4 will take much longer than other transitions because of a need for a critical mass of AVs on the roads before this scenario can play out. It will also require a significant infrastructure build-out that will require significant resources. This infrastructure will include:

> *'side lanes' on highways where autonomous vehicles can pull out in case of technical issues, fully networked intersections and traffic monitoring capability, fully mapped roads with real-time updates, and massive network capability to handle the data needs ……*

Morgan Stanley (20150 cites liability of fault in a crash as the leading barrier for phase 4 and notes other potential obstacles including gaining customer acceptance, building sufficient infrastructure, government regulation and ethical issues.

The International Transport Forum (ITF) (2015) describes two incremental pathways towards full automation.

> *The first path involves gradually improving the automation in conventional vehicles so that human drivers can shift more of the dynamic driving task to these systems. The second path involves deploying vehicles without a human driver in limited contexts and then gradually expanding the range and conditions of their use. The first path is generally embraced by traditional car manufacturers and the second by new entrants. The ITF notes that many observers expect there to be a wide range of autonomous vehicles on the market by 2030, and some of these may be self-driving. It is not clear at present, however, to what extent these vehicles will be capable of self-driving in all circumstances.*

The ITF's view is that automated driving will be available for certain situations:

> *…for instance when driving on motorways, parking a car, or handling stop-and-go traffic in case of congestion). Because the human driver must resume active control when prompted to do so, such conditional automation raises particularly difficult issues of human-machine interaction that have not been satisfactorily solved. Fully self-driving cars on the other hand, will not face the same issue of human-machine coordination, although their use will likely be confined to contexts where the vehicle can confidently handle the full range of driving complexity. Such highly specific contexts include particular routes and low-speed operations. Self-driving cars have a much higher potential for disruption. They may be deployed in fleet-wide systems that would fundamentally reshape individual travel and have an impact on industries such as public transport and taxis.*
>
> *High automation is nonetheless challenging because it describes an automated driving system that, once engaged, can always revert to a 'minimal risk condition' should a human driver not resume actively driving. Reverting to this minimal risk condition may be easier in some contexts (e.g. low-speed parking facilities) than in others (e.g. urban expressways) For this reason, a highly automated driving system is capable of operating in some, but not necessarily all, contexts or 'driving modes'.*
>
> *Such a system of automated vehicles might eventually function in many traffic and weather conditions on many roads in many communities. Nonetheless, these vehicles would not reach full automation unless they handled "all roadway and environmental conditions that can be managed by a human driver.*

The ITF (2015) concludes that whereas motorways may be the most promising early application for increasingly automated conventional cars and trucks, urban areas are well suited for specialised passenger and delivery shuttles. It observes that motorway automation may be an early use case for conditional or high automation in conventional vehicles. Although speeds are high, motorways tend to be more uniformly designed and better maintained. Vehicle flows are more organised, and bicyclists and pedestrians are generally absent.

The ITF (2015) emphasises that dedicated lanes and vehicle platoons are supported by motorway environments. Dedicated lanes facilities will likely require prohibitively expensive retrofitting on existing roads and so be more viable on new roads and high-volume roads.

The ITF (2015) believes that vehicle platoons are a particularly promising application for motorways. A platoon consists of two to six cars or trucks that are closely spaced and tightly coordinated through both vehicle-to-vehicle communication and some degree of automation. A driver may sit in each vehicle, in only the lead vehicle, or eventually in none of the vehicles.

For many urban and suburban applications, the ITF (2015) envisages passenger shuttles and taxis that might operate at low speeds in central business districts, corporate campuses, university campuses, military bases, retirement communities, resorts, shopping centres, airports and other semi-closed environments as well as for first and last-mile public transport applications. It says that delivery shuttles might likewise travel at low speeds along particular routes and at particular times.

Physical infrastructure requirements might include vehicle-to-vehicle and vehicle-to-infrastructure communications equipment, ground-based units for global navigation systems, dedicated facilities comparable to bus and bicycle lanes, on-street parking restrictions, and specific roadway or pavement modifications.

The ITF (2016) provides a selected review of projections for when autonomous vehicles will become generally available:

- IHS Automotive (2014) projects highly autonomous by 2025 and fully autonomous functionality by 2030, with AVs reaching 9% of sales in 2035 and 90% of the vehicle fleet by 2055.
- Navigant Consulting (2013) expects 75% of light-duty vehicle sales to be automated by 2035.
- The Insurance Information Institute (2014) claims that all cars may be automated by 2030.
- Executives at Audi believe fully AVs are still 20 to 30 years away.
- Executives at Bosch believe full automation is beyond the 2025 time frame (Bankrate 2016).

Importantly, despite the optimism, there is a prevailing view reported by Truett (2016) that fully autonomous vehicles will be taken up only in a long term, well beyond 2035[2], while vehicles of various levels of autonomy will be available by 2035, but constitute only a small proportion of the total vehicle fleet.

[2] www.autonews.com/article/20161010/OEM06/310109972/fully-autonomous-vehicles

**Box set 1 Industry leaders expectations for arrival of autonomous vehicles excerpts from Truett (2016)**

**Fully autonomous vehicles won't arrive for a long time**

Experts say a fully automated vehicle that is 100% safe 100% of the time and can operate on any street in any weather condition in the US is not right around the corner.

It's a decade or more down the road.

That assessment, from Raj Rajkumar, co-director of the General Motors-Carnegie Mellon Autonomous Driving Collaborative Research Lab, is shared by other experts at other schools and elsewhere. Carnegie Mellon, the crucible of autonomous vehicle technology, has been working on self-driving vehicles since the 1980s.

The obstacles to perfecting and mass producing fully automated vehicles that can safely transport a passenger door-to-door with no human intervention are formidable: Sensing equipment, such as cameras, lidar and radar, has to get more efficient, especially in inclement weather. It also must get less expensive.

Software has to be perfected that links the vehicle's controls with all the sensing hardware. And this software must be able to anticipate nearly every scenario a vehicle can encounter, from inclement weather to a traffic cop's hand signals to a pedestrian darting into traffic.

Infrastructure needs to be improved, from lane markings to traffic signals to bridges – as well as the vehicle-to-vehicle and vehicle-to-infrastructure communication systems. For a vehicle to drive itself safely in all conditions and speeds, it has to know where it is at all times so that, for example, it anticipates a stop sign around a corner.

'We as humans have common sense and reasoning powers that we apply, and most of the time, if not always, we do the right thing,' said Rajkumar. 'Computers, though very powerful, are unfortunately lacking in common sense.

'Self-driving cars can only do what programmers tell them to do. They can't anticipate everything that can happen on the road.'

Communication from automakers also can be confusing. Few automakers are promising a fully autonomous vehicle, classified as a Level 5 vehicle by SAE International. But some marketing names, such as Tesla's Autopilot, give the impression that cars with limited autonomous technology can drive themselves safely at all times.

Consumers also might not notice some of the qualifications in automakers' forecasts.

For instance, in August, Ford CEO Mark Fields said by 2021 his company aims to be making a self-driving car that eliminates the pedals and steering wheel. But this vehicle would be a Level 4 autonomous vehicle, to be used only in certain areas and conditions. Fields said that Ford's car would be used by ride-hailing and ride-sharing services in a geo-fenced area, which means it would be limited to streets that have been mapped and programmed into the vehicle's software.

Such an area could be the small part of Pittsburgh where Uber is testing self-driving cars this fall, or a closed area such as the General Motors Technical Center in Warren, Mich., where automated Chevy Volts will be used to transport GM engineers this year.

**Toyota: More testing**

Ford's ambitious claim – and others like it – has some doubters.

Last month at the Paris auto show, Toyota President Akio Toyoda said fully autonomous driving, which the company calls chauffer mode, will require lengthy validation.

**Safer than humans**

Huei Peng, director of the University of Michigan's Mobility Transformation Center, says self-driving technology is maturing quickly and that more automated driving features are coming soon. But it may be decades before a vehicle can drive itself safely at any speed on any road in any weather.

Peng said he sees Level 4 automated driving at low speeds in good weather happening by 2021.

'I would argue that if you just talk about technology and reasonable operating conditions,' Peng said, 'we can almost say we have systems that are safer than human drivers'. He cited Google's self-driving car fleet, which has logged more than 2 million autonomous miles and caused just one minor accident.

The Google test fleet operates 58 vehicles in four states. 'Robots always work best when they have rules,' Peng says. 'What if other people are not following the rules? In the truest sense, Level 5 autonomous vehicles will take a very long time.'

### 3.3.3 The impact of electric vehicle technology

The potential widespread introduction of electric vehicle technology is an important development for connected mobility outcomes for society. While not essential for ITS implementation, electric vehicles offer many opportunities for consumers, in the context of ITS, that internal combustion power trains do not. Electric vehicle technology is comprehensively covered by Arbib and Seba (2017) and is not further discussed here.

Electric vehicle technology has the potential to speed up the take up of autonomous vehicles, primarily because of the cost saving per user that it will provide, as outlined by Arbib and Seba (2017). The report's projections of a widespread collapse in the consumption of oil is somewhat extreme. There are many barriers to widespread take-up of electric vehicles that must be overcome, including their safety, the provision of recharging facilities and the sustainability of the supply of Lithium batteries (or substitutes thereof).

### 3.3.4 Transitional arrangements – platoons and road trains

Morgan Stanley (2015) believes that platoon technology would support the introduction of semi-autonomous rigs and, potentially, broad adoption of the technology within 15 years. Truck operators could 'tether' rigs together and move in convoy fashion over long distances. Initially, these convoys would involve a lead human driver (or driving team) followed in close formation by any number of trailing rigs, which are self-driven to follow the lead truck and are tethered through the technology (we call this semi-autonomous as it still requires a human lead manual driver team).

Morgan Stanley (2015) also believes that autonomous and semi-autonomous driving technology will be adopted far faster in the cargo markets than in passenger markets because humans are far more comfortable with autonomous technology operating vehicles in circumstances when human life is not at risk. Morgan Stanley says that long-haul freight delivery is one of the most obvious and compelling areas for the application of autonomous and semi-autonomous driving technology. This is because driving on state highways is one way and predictable.

State highways are also supportive of road trains for cars. A road train is made up of a number of cars in formation, closely following each other as a 'platoon' until cars need to peel out of the pack to different destinations. The cars will be in semi-autonomous mode when in the platoon. In its current form, each platoon would be led by a bus or truck. The cars can merge into and out of the platoon with relatively small gaps through V2V communication and coordination.

The advantages of this concept are that cars can drive autonomously in safety, achieve significant fuel economy improvements as a result of the 'drafting effect' of the platoon, and reduce congestion.

Morgan Stanley (2015) cites the SAfe Road TRains for the Environment (SARTRE) project, led by Volvo and completed in 2012, as providing a prototype of how autonomous and non-autonomous cars can coexist on roads for a few years until AVs achieve full penetration. The SARTRE project was an initiative funded by the European Union that studied the feasibility of implementing a road-train system on highways.

**Box set 2 £8.1m funding released for UK's first autonomous truck trial (Source: Druce 2017)**

| |
|---|
| The platooning trial will see up to three HGVs travelling in convoy, with acceleration and braking controlled by the lead vehicle.<br>Each lorry will have a driver ready to take control if necessary, the DfT said.<br>The government believes the technology could have benefits for motorists and businesses.<br>Lorries driving closer together could see the front truck pushing the air out of the way, making the vehicles in the convoy more efficient, lowering emissions and improving air quality, it has claimed.<br>Transport minister Paul Maynard said: 'Advances such as lorry platooning could benefit businesses through cheaper fuel bills and other road users, thanks to lower emissions and less congestion.<br>'But first we must make sure the technology is safe and works well on our roads, and that's why we are investing in these trials.'<br>The Transport Research Laboratory will carry out the trial, with Highways England also supporting the project. DAF, DHL and Ricardo will be involved.<br>The trial will be carried out in three phases, with the first focusing on the potential for platooning on major roads.<br>Initial test track-based research will help decide details such as distance between vehicles and on which roads the tests could take place.<br>Trials are expected on major roads by the end of 2018.<br>RHA chief executive Richard Burnett said: 'Of course we welcome improvements to the way the road freight industry works and we understand the benefits that such a mode of operation would bring.<br>'However', he continued, 'currently the focus seems to be on the technology behind the system. Safety has to come first and it cannot be compromised. It is crucial this element of the concept gets the highest priority.' |

Note: 'DfT' means Department for Transport, UK; 'DAF' means DAF Trucks NV, a Dutch truck manufacturing company; and 'RHA' means Road Haulage Association, UK.

## 3.4 Conclusions

In this chapter we have outlined the diversity of ITS technologies. As ITS technologies are implemented, there will be certain combinations of these at various stages and for specific locations to support various levels of AVs. We conclude that fully autonomous or near fully autonomous vehicles in controlled environments will likely lead ITS implementation by 2035. At the same time, various levels of semi-autonomous vehicles will be continuously improving. As a broad estimate, for a global perspective, it is likely that ITS implementation in 2035 will be characterised by vehicle fleets with up to 20% of fully autonomous vehicles, mostly in controlled environments.

On this basis, we expect a percentage lower than 20% to apply for New Zealand in 2035 in part because we are technology followers. This is consistent with our New Zealand-specific assessment in chapter 5. These percentages will characterise the state of development of ITS implementation present in our technology scenarios that, in turn, provide a context for the skills gap assessment for 2035.

# 4 Future skills gaps and training needs in the UK and USA

## 4.1 Overview

This chapter presents snapshots of projected skills gaps and training needs for likely future ITS environments, from the US and the UK. These provide a ready comparator to our own results for New Zealand reported in chapter 6.

These assessments are concerned almost entirely with skills gaps due to excess demand. By comparison, our assessments included skill gaps resulting from reduced demand for non-professional occupations such as for commercial drivers and automotive technicians.

## 4.2 UK and USA projected skills gaps

### 4.2.1 UK skills gap projections to 2025

Transport Systems Catapult (TSC) (2016) launched an Intelligent Mobility Skills Strategy (IMSS) in October 2016, informed in part by an evidence-based report on skills demand, supply and associated policy intervention to support growth of the UK intelligent mobility market. Forty key stakeholders were consulted and a workshop with over 20 industry participants helped to validate the findings of the report.

Importantly, the findings of the report led to a skills gap assessment that projected future gaps in a wide range of disciplines from physical and technical sciences to social and human sciences. These are summarised in figure 4.1, from figure 4 of the TSC (2016) report.

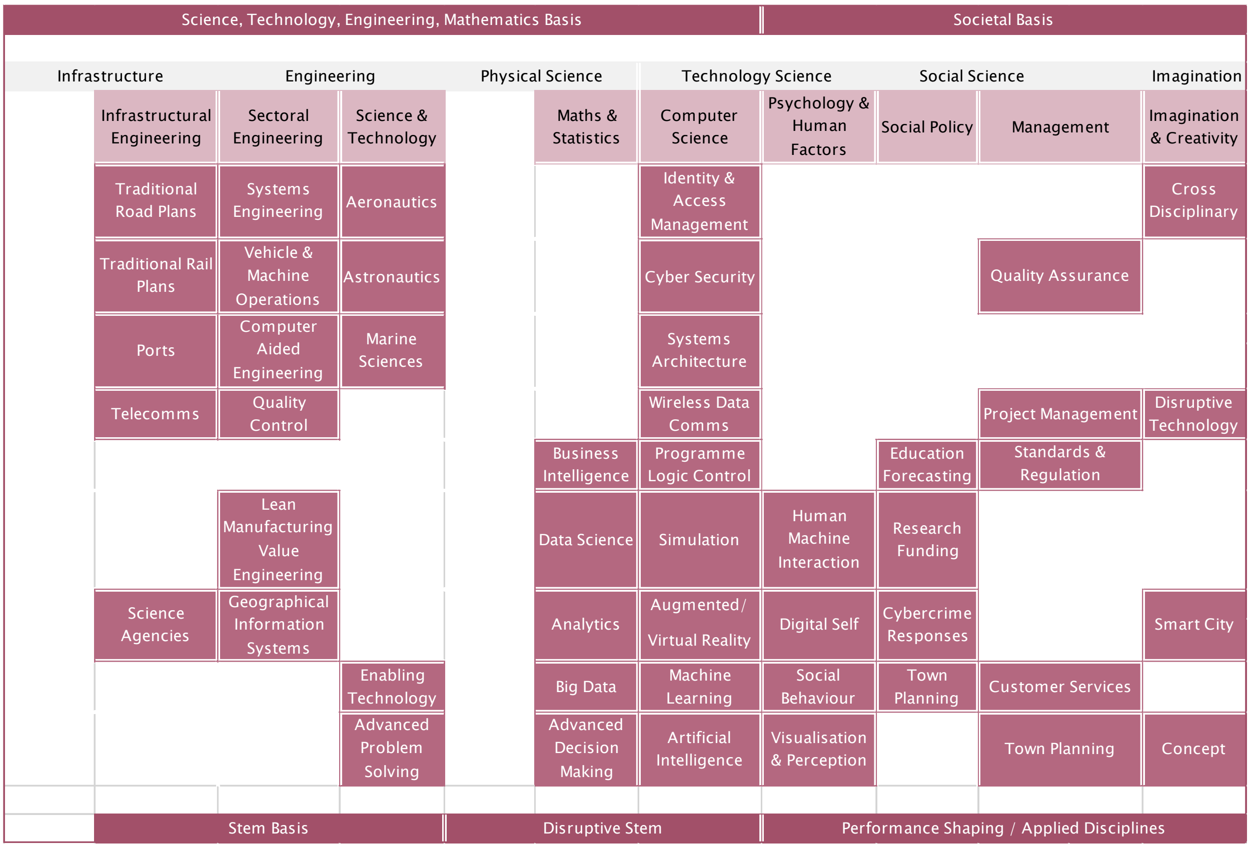
The evidence gathered indicated that the compound annual growth (CAGR) rate of constituent ITS market segments of between 5% and 25% over the coming decade – with the exception of the autonomous vehicles segment, which is predicted to grow at 58% CAGR over the same period, albeit from a low base.

There is valuable detail in the table that qualitatively illustrates the breadth and depth of future skills gaps from science, technology, engineering and mathematics (STEM) disciplines to performance shaping and applied disciplines that encompass social science and creative disciplines.

The key findings of the report include:

- The UK faces a potential skills gap of 742,000 people by 2025.
- Disruptive skills (high-value digital skills) that will reinvent transport systems and create new businesses are in short supply. Of the overall shortfall, 281,000 are disruptive skills.
- Transport industry experts strongly prefer higher degree apprenticeships to address future skills gap.
- A nationally coordinated and integrated range of traditional and disruptive interventions is needed to address the skills shortfall:
  - spanning from early education to post graduate training
  - supporting transfers and skills growth from across other sectors
- Proactive efforts need to be made to attract women to the industry.
- New ways of rapidly developing digital skills can be adopted.

**Figure 4.1 Transport Systems Catapult skills gap assessment**




These qualitative findings are helpful for the New Zealand skills gap assessment since they highlight wide-ranging demand, particularly for social science and creative disciplines.

A summary of skills gap predictions to 2025 across all sectors is shown below in table 4.1 from table 3 of the TSC (2016) report.

Importantly, from a training perspective, the TSC (2016) report identified a clear need for the transport sector as a whole to work collaboratively to ensure that skilled staff are agile in their skills and thus able to move from project to project and, indeed, into and out of allied sectors, such as energy.

A key message from the TSC (2016) report is the impact data has across the transport sector and the need for future workers to have the capability to manipulate, analyse and model large amounts of data in real time. This has not been a historic focus of traditional transport engineering career paths.

Another key message of the report is the likely future demand for technology-driven solutions to meet needs for shared transportation services. This will require the incorporation of information technology teaching, as well as design and human-centric disciplines, into ITS skills development.

**Table 4.1 Transport Systems Catapult skills gap estimates to 2025 across all sectors**

| Skills arena | IM skills demand 2025 | IM skills supply 2025 | IM skills gap 2025 | Relative skills gap 2025 |
|---|---|---|---|---|
| Infrastructural engineering | 465,750 | 177,000 | 288,750 | 62% |
| Sectoral engineering | 165,000 | 28,000 | 137,000 | 83% |
| Science and technology | 60,000 | 25,000 | 35,000 | 58% |
| Maths and statistics | 193,200 | 50,000 | 143,200 | 74% |
| Computer science | 142,800 | 13,000 | 129,800 | 91% |
| Psychology and human factors | 15,000 | 14,000 | 1,000 | 7% |
| Policy | 25,000 | 25,000 | 0 | 0% |
| Management | 87,500 | 85,000 | 2,500 | 3% |
| Innovation and creativity | 5,000 | Not known | 5,000 | 100% |
| **Total** | **1,159,250** | **417,000** | **742,250** | **64%** |

Note: IM = Intelligent mobility

### 4.2.2 US projected skills gaps

A projected ITS skills gap assessment for the US is provided by the Workforce Intelligence Network for Southeast Michigan (WIN) (2017) study of future workforce demands for CVs. WIN partnered with the University of Michigan Transportation Research Institute to analyse job postings for a broad set of occupations that may be involved in the design, manufacture and infrastructure development included in the CV product cycle.

Key findings include:

- Diversity of occupation domain: workers will be needed from a diverse array of occupations signalling the difficulty in identifying a complete workforce and set of skills for future training.
- Undefined occupations: CV industrial development is just commencing and there are yet no standard occupation statistical codes to precisely define related workers. Instead, data such as online job advertisements for emerging job positions serve as a proxy.
- Occupations in recent demand to 2016 are for information technology, information security and computer systems.
- Qualifications attained are sought at bachelor’s level, at minimum, and many employers seek talent with several years of experience.
- Community colleges have an opportunity to provide baseline training or upskilling necessary for workers.
- A federal-level security clearance is one of the most sought-after certifications for connected and automated vehicle workers, making the requirements even more stringent on who can join this workforce.

The most in-demand jobs with CV skills posted in the US between October 2015 and September 2016 are IT-related. The top three, software developers, information security analysts, and computer systems engineers, are associated with cybersecurity, IT design and managing the data related to connected transportation systems. Demand for these three occupations represents 61% of all CV-related demand in the US.

US employers looking to hire workers with CV-related skill sets are competing for workers in one of the most in-demand and highly specialised fields nationally. Software developers are routinely one of the top in-demand jobs overall. Between October 2015 and September 2016, employers in the US posted nearly 800,000 software development jobs. Job advertisements that listed CV skills (2,546 postings total) represent only 0.3% of all software development postings.

Vehicle design and testing requires the involvement of many engineers in the ongoing research, design, and testing of CV projects. Many types of engineers are required, including electrical engineers, mechanical engineers, and commercial and industrial designers. These are associated with early development and design of vehicles, aftermarket devices and connected infrastructure. Since 2011, employer demand for occupations in this group has nearly doubled.

Vehicle manufacturing occupations already exist at original equipment manufacturers (OEMs). Workers in this sub-group include industrial engineers, mechatronics and robotics engineers, and team assemblers – workers needed generally throughout the vehicle manufacturing process. Additional training of existing employees may be necessary for workers to understand new equipment and processes involved in manufacturing an AV. Employer demand for occupations in this group has nearly doubled.

Vehicle IT design workers develop hardware and write software for use in CVs and AVs. Computer hardware engineers working on CV and AV projects are developing hardware for fully automated vehicles as well as after-market devices designed to retrofit the existing fleet. Computer programmers and software developers write code that governs the automation of the vehicles, with an eye toward safety. Job postings have increased by 46% to 3,089 postings from 2013/2014 to 2015/2016.

Data management and cybersecurity occupations cover data warehousing specialists, information security analysts, and other computer- and network-related occupations. These workers participate in projects where data is collected and communicated by connected infrastructure and AVs. Skills necessary for these occupations will be valuable to private owners of the new data as well as private individuals concerned for their physical safety and privacy.

According to the WIN (2017) report, demand for intelligent transportation systems and infrastructure workers in 2012/2013 was greater than ever before. Skilled and knowledgeable workers like these will be key in the implementation of connected vehicle infrastructure and ITS. Telecommunications specialists and civil engineers will also work closely with transportation planners and engineers and traffic technicians within this sub-group to inform decision making on connected infrastructure and traffic management. Therefore, workers in this sub-group may work for state and local transportation departments or private consulting firms. Online job advertisements have increased nationally over the past three years but demand is not growing as quickly as in other areas of CV. This may be because intelligent and connected transportation systems are further in the future than vehicle and IT design.

## 4.3 Global projected training needs

### 4.3.1 UK training needs

The TSC (2016) strategy described above identified a set of interventions aimed at providing the required training for ITS skills development to 2025. In summary these are:

- the creation of a 'hub' that is a shared learner repository providing industry standards, signposting training to support upskilling, skills planning and gap analysis
- ensuring that all existing STEM apprenticeship frameworks include an element of ITS training

- the development of higher degree apprenticeship frameworks with industry and academia to produce capable and work-ready graduates
- developing innovative science school training programmes using existing technology centres
- building cross-sectoral collaboration
- creating new academic qualifications that also build awareness and create a pipeline of talent
- participating in and influencing new and existing government initiatives to enhance industry collaboration and accelerate impact
- building professional development and accreditation
- creating opportunity for all and closing the gender gap
- raising awareness of ITS through targeted marketing and advertising campaigns across the UK.

### 4.3.2 USA training needs

The US DoT (2015b) believes:

- innovation-driven ITS infrastructure will require an educated and motivated workforce
- this workforce will develop, deploy and diffuse technology, requiring the active collaboration of all sectors of the economy: government at all levels, industry, labour, education and the research community
- these sectors must pool their resources to ensure that a capable well-trained workforce is readily available – one with the skills to create, embrace and use rapidly evolving ITS technologies

From a skills perspective, the DoT says:

- today's transportation professionals must adapt to a continuous infusion of new and emerging V2V, V2I and automation technologies
- it is no longer sufficient to have a technical background or to view transportation education as just a series of tertiary education courses
- tertiary education is required that views attainment of transportation skills as an ongoing life-long, multi-disciplinary endeavour.

In the US, to prepare the next-generation transportation workforce for ITS implementation, the Professional Capacity Building (PCB) programme of the DoT (2015b) sees a need for overarching collaborations of educational institutions and public and private sectors to supplement the traditional focus on technical issues with training in transportation management and policy, and embrace a systems engineering approach to transportation.

The PCB is an important part of the US DoT's (2015a) strategy for ITS. According to the PCB, ITS education requires a cross-disciplinary approach to developing knowledge and skills in variety of disciplines, including traditional subject areas such as civil engineering as well as non-traditional areas subjects like computer science, mathematics, electrical engineering, cryptography and urban planning. This will involve retraining of existing engineering professional together with new types of training delivered by tertiary education organisations.

Key resources of the ITS PCB program include: (i) web-based training; (ii) classroom learning; (iii) targeted training such as in workshops and conferences; (iv) reference and resource materials; and (v) assistance from expert peers.

The Consortium for ITS Education and Training (CITE) is a consortium of over 100 university and industry partners. CITE develops interactive on-line courses. Courses for continuing educational units are available through CITE as well as college level for-credit courses. CITE university partners have full access to all course materials at no cost.

The US DoT is required under the current transportation authorisation legislation ‘to develop a workforce capable of developing, operating, and maintaining intelligent transportation systems’.

The PCB programme makes the following recommendations to address tertiary level ITS education needs:

- Conduct a core competency study. This is necessary to map competencies needed for ITS/CV, followed with a gap analysis with specific recommendations for how the ITS PCB programme can best address these gaps.
- Expand university engineering programmes to encompass increased content of general and specialised courses.
- Develop stand-alone certificate programmes that can be achieved by busy professionals at low cost.
- Increase course offerings and professional improvement courses in ITS/CV on-line that utilise cross-sector collaborations and synergies.
- Support technical schools (such as industry training organisations) to provide appropriate technical training and to encourage non-degree qualification attainment.
- Support firms to institutionalise education and training in their day-to-day operations. This will enable education and training to be tailored, targeted and accessible.

The PCB programme believes that education programmes must be considered in an integrated manner that includes secondary and tertiary training institutions. These should also utilise new training delivery methods to reach the varied audiences.

Transcripts of webinar discussions of the PCB programme concerning the future CV workforce indicate that future ITS education programmes are likely to be highly multi-disciplinary and diverse. For this reason, it will be challenging to include them in the undergraduate curriculum.

Public-private collaborations may provide a solution to training needs. This demonstrates the flexibility needed in training courses in order to respond to the impact of technological change.

One example of collaboration is in the production of national training guidelines in the US by the American Public Transportation Association (APTA 2015).

APTA’s (2015) *Working together: a systems approach for transit training* programme outlines how constructive training partnerships provide the most effective way for the public transport industry to address its skill challenges. National labour-management committees have met regularly for several years to develop consensus training guidelines. These joint committees have been focusing on five public transport maintenance occupations: bus, rail signals, traction power, rail vehicles and elevator/escalator. A parallel joint effort has been crafting a national framework for public transport apprenticeship. Consensus national training guidelines make it possible for public transport organisations and partnerships to assess the current skills of their workforce through a skills gap analysis. They can use the guidelines to conduct a training gap analysis that measures the quality of their current curriculum and training materials. After identifying current skills gaps and training gaps, the recommended guidelines can be used to create a customised training improvement plan.

## 4.4 Conclusions

### 4.4.1 Global skills gap assessments

In summary, recent national skills gap assessments have indicated that ITS implementation will result in increased demand for skilled professionals in many fields, including cybersecurity, IT design, data management and data analytics, and human centric fields. Some of these fields such as vehicle manufacturing are not relevant to New Zealand. The studies do not cover technically skilled workers such as automotive technicians and drivers.

There is a considerable emphasis on ICT skills. However, the international studies do not analyse this demand in any detail. In particular they do not highlight the extent to which such skills may themselves be automated and provided from one machine to another, such as with machine to machine (M2M) processing. Such application of automation may address part of the increased demand for big data skills.

There is a need for skills to enable workers to be agile and collaborative

The TSC Catapult (2016) study identifies a comprehensive range of skills in demand that provides useful guidance to the present report. However, the TSC Catapult report does not analyse how multiple skills may be supplied by the same individuals and the way that multi-disciplinary collaborations, networking and outsourcing can meet skills needs.

These issues and others are considered in further detail for New Zealand in the following chapters.

### 4.4.2 Global training needs assessments

Reports of the UK and the USA indicate that new training methods to address ITS skills development should:

- be guided by a skills gap assessment and a career pathway
- include new knowledge bases for ITS disciplines
- include on the job training, including for professional occupations
- facilitate cross-sectoral collaboration
- create recognisable accreditation for new training consistent nationally and across industries
- provide opportunities for life-long continuous education
- include training in non-traditional disciplines
- involve cross-sectoral governance and leadership
- include targeted courses in curricula.

# 5 ITS technology scenarios for New Zealand in 2035

## 5.1 Introduction

The economic framework presented in chapter 2 identified that technology changes produce skills changes, which in turn produce qualification changes. Hence before we can assess skills changes, we need an understanding of the likely technology in a future state that an ITS environment will provide. This will allow us to assess skills gaps in the future state consequent on changes in skills demand due to the implementation of new technology.

As we noted in chapter 3, the state of ITS development can be defined by a collection of ITS technologies that are continuously improving to achieve very long-term outcomes for connected mobility. Connected mobility is shaped by both technological change over time and also non-technological factors. Technological factors (such as level of autonomy) also influence non-technological factors (such as public acceptance) and vice versa.

The future state of connected mobility in the very long term can be defined in terms of outcomes that society desires and are achievable. Society will make progress towards these long-term outcomes. In the very long term, when these outcomes are achieved, ITS technologies will be fully developed. In the interim, particularly at 2035, some of the ITS technologies will be present in various stages of development.

The progress to the achievable outcomes described above will likely take place along an S-curve, as discussed in chapter 2. In 2035, progress towards outcomes will be identified as a place on an S-curve, in the same way that ITS technological development will be at a place on an S-curve.

This chapter begins by presenting achievable outcomes likely to be desired by society for connected mobility. It then discusses the pace of ITS transformation to connected mobility using the pace of adoption of AVs as a proxy for this pace, in line with the discussion in chapter 3.

We then present five plausible states of connected mobility for New Zealand at 2035, in terms of the technologies themselves as well as non-technological factors, such as business demand, household demand and public policy. The five states in 2035 can be described as being points on the five different S-curves of technological change for ITS that we presented in chapter 3. Each state is the result of a different plausible progress path for ITS technology from the present. Each path is shaped in different ways by both technological and non-technological factors.

The five states provide a context to develop plausible skills gap assessments and training needs in subsequent chapters.

## 5.2 Achievable outcomes for connected mobility

Achievable connected mobility outcomes for New Zealand are illustrated in the priorities of the MoT (2017) report for the Auckland Transport Alignment Project (ATAP). The overarching outcomes of the project help define detailed ITS technology needs, and, by implication, the demand for future skilled workers to implement them. The overarching outcomes are:

- intelligent network management;
- emerging vehicle technology

- shared mobility
- data collection and analysis.

Intelligent network management encompasses a wide variety of distinct interventions designed to enable a comprehensive real-time understanding of network use, the ability to intervene to dynamically manage travel demand, and the associated data processing capability to perform these functions. Examples include: provision of sensors on the network to monitor traffic movements; adaptive traffic signals; dynamic lanes or information provision to manage demand; and staff capable of using advanced analytical tools to manage the transport network in real-time. Benefits of intelligent network management include: improved optimisation of existing transport infrastructure (for example by managing traffic flows in response to congestion or incidents); better targeting of maintenance and renewals expenditure; and better planning of new infrastructure investment.

Emerging vehicle technologies will provide future connection and automation. CVs enable communication between vehicles, infrastructure and other connected devices. Automated vehicles are equipped with technology which enables self-driving features, ranging from partial automation (like single-lane motorway autopilot, closely monitored by the driver), through to fully autonomous vehicles (which require no driver monitoring). Connected and automated vehicles have the potential to significantly improve network performance by increasing lane capacity (through shorter following distances and mitigation of start-stop shockwaves), improving safety (by removing human error, the cause of around 80% of traffic crashes), and improving travel time reliability.

Shared mobility is also key to the uptake of MaaS – the concept that urban travel can be consumed as a service, rather than provided through personally owned modes of transportation. MaaS could work by combining public transport and shared mobility options through a single system (for example a smart phone app), which recommends, manages and pays for the trip.

Data collection, analysis and distribution is at the heart of intelligent network management. Without a clear picture of network use, better investment decisions and real-time management of travel demand is not possible. Data collection by sensors across the network provides improved network performance and better travel demand management. Sensors, however, are expensive and cheaper data sourced from third parties will likely be utilised in future. Such data can be sourced from the wider IoT, including from smart phones, wearable devices and connected vehicles. Coupled with using data from different sources, various software (some open sourced) will likely be used to interpret and analyse transport data; to help inform decision making; and to entertain. In addition to data collection and analytical tools, a skilled workforce capable of managing a smart transport network will be needed. Skilled workers in analysis and management of transport networks together with new kinds of vehicle controllers and automotive technicians will be required in the future. What is not clear is the level of deployment and use of these technologies, both alongside and in substitution for existing technologies. That and the trajectory of deployment will determine the skills required of future workers.

## 5.3 Potential timing of ITS implementation

Two reports for New Zealand illustrate the timing of progress for the achievement of connected mobility:

- the ATAP report of MoT (2017)
- the Synergine (2015) report.

### 5.3.1 ATAP report

The MoT estimates it could be at least 10 years before connected autonomous vehicles start to make a significant difference to network performance. Importantly, the ATAP report notes that lower costs expected from driverless cars will provide a significant incentive for people to use shared CVs rather than private vehicles and some public transport services.

Table 5.1 below reproduces projections of ITS implementation from the ATAP report. It shows the proportion of the vehicle fleet estimated by ATAP to be automated (according to level) and connected, with broad ranges reflecting uncertainty about the speed of technological development and commercialisation and the degree to which central or local government interventions could accelerate uptake. The table shows that as higher levels of automation enter the vehicle fleet, the proportion of vehicles equipped only with lower levels of automation declines as older technology is updated.

**Table 5.1 ATAP report projections of automation of the vehicle fleet**

| | 2026 | 2036 | 2046 |
|---|---|---|---|
| Level 0 – No automation | 59%–79% | 15%–38% | 5%–15% |
| Level 1 – Driver assistance | 15%–30% | 33%–40% | 5%–25% |
| Level 2/3 – Partial/conditional automation | 5%–8% | 10%–20% | 10%–35% |
| Level 4 – High automation | 1%–2% | 7%–17% | N/A |
| Level 5 – Full automation | <1%–1% | 5%–15% | 25%–80% |
| Cooperative adaptive cruise control | 6%–11% | 22%–52% | 60%–90% |

In the ATAP report, the MoT comments that if shared fully autonomous vehicles become widely adopted, the impact on public transport demand could also be material. The ATAP report cites research that indicates the cost per passenger kilometre of fully autonomous vehicles could potentially be similar to that of traditional subsidised public transport and significantly cheaper than taxis, while offering a broadly equivalent level of service to private vehicle travel (in urban environments).

### 5.3.2 Synergine

In a report for Auckland Transport, Synergine (2015) concludes that there will be a long lead time for CV implementation.

> *Current market intelligence suggests that the vehicle fleet transition to CAV technologies may take several decades, however the potential for unanticipated technological leaps, or barriers to progress, could significantly affect these estimates. From early stages of the fleet transition, safety, environmental and accessibility benefits can be generated, increasing in proportion to the share of fleet uptake…A 50 percent fleet transition to CVs is predicted to arrive by 2055 (Litman, 2017), and could enable a 22 percent improvement in effective road capacity.*

Four future scenarios are hypothesised by Synergine, based on the variety of ownership models and vehicle forms that may be used to implement CV technology with optimisation according to the value proposition for private firms, public sector agencies and individual travellers.

The Synergine report says that scenario A is a likely transition phase for all scenarios:

#### 5.3.2.1 Scenario A

Uptake of CV technology initially grows rapidly; however, barriers to widespread implementation limit its use to specialised functions. This scenario is likely to be a transition phase for all other scenarios, while the cost of technology remains high or regulatory provisions are still under development. The possible length of this phase is uncertain, and may hinge on the interdependence between legal, economic and technical systems to produce a CV product or service that is safe, reliable, affordable and with provision for crash risk.

#### 5.3.2.2 Scenario B

CV technology implemented by car-sharing or ride-sharing operators has the predominant market share for urban travel. MaaS provided by CVs accounts for approximately 80% of vehicle travel within 30 years. Private operators of car-sharing or ride-sharing services, such as Uber or Zipcar, introduce fleets of AVs to provide on-demand MaaS.

#### 5.3.2.3 Scenario C

CV technology in private vehicles has the predominant market share for urban travel, and fleet transition occurs over 50 to 60 years. Non-drivers, including elderly, disabled, and children, can now make trips that may not have been feasible using public transport services, and the safety features of CVs have dramatically reduced the number of fatal incidents on the road network.

High levels of private ownership of CVs requires the cost of new vehicles to fall to a level that is affordable for most individuals or households, and that public transport or car-sharing services remain relatively expensive, or offer a lower level of service.

#### 5.3.2.4 Scenario D

CV technology is implemented by public transport providers, and expansion of the public transport network enables it to support approximately 50% of urban travel within 30 years. In the form of driverless buses and shuttles, public transport providers exploit the potential to increase the coverage of their networks without a corresponding increase in labour costs. Shuttles are introduced alongside bus or bus rapid transit as 'feeder services' to existing public transport networks, in more sparsely populated areas.

## 5.4 ITS scenarios for New Zealand in 2035

### 5.4.1 ITS technology assessment

We conclude from the findings of:

- the ATAP report
- the Synergine report
- selected perspectives from other countries

that by 2035, ITS implementation will likely result in a limited take-up of ITS technology associated with:

- a high level of semi-autonomous vehicles, up to about 37% of the national vehicle fleet at levels 2 to 4 of autonomy
- a low level of fully autonomous vehicles, up to about 15% of the vehicle fleet, but concentrated in controlled domains
- a proportionately greater take up by businesses and passenger fleet businesses than households

- a lower motor vehicle crash rate overall due to the enhanced safety benefits that semi and fully autonomous guidance provides
- a sizeable proportion of transport management dedicated to supporting controlled domains and to developing new ones
- a widespread take up of ICT technologies associated with both embedded and nomadic telematics.

### 5.4.2 Contribution of technology and policy and participation of users

With this perspective, together with learnings from global reports, and with New Zealand expert views, we assess the impact of each of the seven influencing factors for the S-curves described in chapter 2 in supporting the level of ITS implementation in our selected five scenarios. That is, we assess, for each S-curve scenario, the likely contribution of technology and policy, together with the participation of users at 2035.

We express this impact in terms of a rating of high, medium and low. We show these in table 5.2 and for vehicles and non-vehicles, where:

- for vehicles, L means SAE (2016) level 1 to 2; M means SAE level 1 to 3; H means SAE level 1 to 4.
- for non-vehicles, L means minimum level achievable by 2035; M means medium of level achievable by 2035; H means maximum level achievable by 2035.

Though illustrative, this technology assessment provides a composite indication of the state of autonomy of vehicles, the readiness of society for ITS implementation, the enthusiasm of businesses, etc. In doing so the assessment:

- provides guidance for the skills gap assessment because we can assess the extent of technological change and therefore estimate its impact on skills demand
- provides upper and lower bounds to this impact with two extreme scenarios of rapid progress and slow progress
- illustrates the complementing but different impacts of the factors likely to prevail.

In assessing the impact of each of the seven factors, we assume:

- New Zealand is likely to be a follower in the adoption of ITS technology. In part this is because ITS deployment will require some level of public infrastructure and regulatory oversight, which are costly to initiate and develop.
- ITS will also require some investment in fleets of AVs by private and public organisations, together with provision of support services.
- In part New Zealand will follow technology implementation in Japan (which is expected to be very fast) due to the significant proportion of Japanese imported new and used vehicles into New Zealand. This exemplifies the influence of public acceptance of AVs.
- It is reasonable to assume that ITS in New Zealand is likely to be implemented first in controlled areas with dedicated infrastructure, where economies of scale exist from high population densities near industrial sites.
- Industry, particularly freight transport carriers will potentially seize the profit opportunities presented by fully or near fully autonomous vehicles.

- Households may develop a preference for AVs (semi- or fully) for some or of their transport needs, including commuting to work and connecting with other transport modes.
- Local and central government may realise the benefits of ITS by subsidising AV use, with dedicated lanes and other measures.

**Table 5.2 ITS implementation scenarios at 2035 for New Zealand**

| Progress path scenario in the very long-term | Technologies | | | | Transport users | | Public policy | Connected mobility outcome in the very long term |
|---|---|---|---|---|---|---|---|---|
| | Vehicles | Data analysis | Infrastructure national | Infrastructure local | Busi-ness | House-holds | | |
| 1 Slow | L | M | L | L | L | L | L | Business as usual |
| 2 Medium with no incentives | M | M | L | L | M | L | L | Agencies reluctant to invest/ subsidise, businesses see benefits |
| 3 Medium with incentives | M | M | M | M | M | M | M | Agencies willing to support/invest and businesses and households cautiously support |
| 4 Rapid | H | H | M | M | M | M | M | Rapid growth in technology and cautious development of confidence |
| 5..Mixed rapid/slow | H | H | L | L | M | L | L-M | Initial novelty/ enthusiastic takeup, long-term households more reluctant to change, barriers exist due to user convenience and cost |

### 5.4.3 Vehicle fleet replacement

The rate of replacement of the vehicle fleet is one reason why a low technology scenario in full or in part may prevail for some years. The light vehicle fleet in New Zealand currently numbers about 3.2 million vehicles. The average age of the fleet is 14 years and the fleet is aging. A large group of vehicles in the fleet is 18 year or older. One observation is that the fleet needs to be younger (ie higher turnover rate) for the benefits of the introduction of new technology vehicles to proceed at a steady rate. Each year about 165,000 used vehicles and about 130,000 new vehicles are imported into New Zealand. At the same time about 150,000 vehicles are scrapped. Japan accounts for about 95% of used vehicles imported into New Zealand. The implication is that the domestic fleet in New Zealand is inextricably linked to the domestic fleet in Japan. This suggests that imports of AVs into New Zealand may follow a similar pace to the implementation of them in Japan, although lagged somewhat. This rate of introduction may be supported by households with multiple vehicles, gradually replacing them with AVs, many of them used imports from Japan. Such household use is likely to involve connected journeys, where AVs are used to connect people with other modes of non-driven transport (such as rail and buses).

## 5.5 Conclusions

In conclusion, the ITS technology assessment in section 5.4 illustrates the way in which contributing technology and policy, together with participating households and businesses will together define the overall level of ITS implementation.

Widespread data analytics are expected to be easily available to support high levels of ITS technology. Similarly, AVs of a very high level are expected to be easily available to provide support, but only in controlled domains. Restriction to these domains represents the influence of policy, together with the preferences of business and households, who will have concerns about many issues including liability, safety and security. At the same time cost factors associated with vehicle replacement will inhibit the take up of ITS technologies.

# 6 Skills gap assessment for New Zealand in 2035

## 6.1 Introduction

This chapter presents qualitative assessments of skills gaps and associated qualifications that are likely to prevail in the period to 2035. Current and future supply of skilled workers is provided by new trained entrants to the workforce, re-trained current workers and trained migrants. Retiring workers and migrants reduce this supply. Current demand of skilled workers by industry is determined by economic conditions. Skills gaps arise in the present context, when workers with relevant skills demanded by industry in an ITS technology environment are not available in sufficient numbers to meet industry demand.

There are presently skills shortages in many ITS related occupations, which have prevailed for many years. The skills gap assessments outlined in this chapter were made in consultation with stakeholders and experts who were fully cognisant of current shortages in their respective areas of interest. Chapter 7 outlines the present understanding of these skills shortages.

Two workshops were convened in Auckland and in Wellington in June 2017 to consult diverse stakeholders from throughout New Zealand on likely transport-related skills gaps in 2035 and training needs to address them. These skills gaps were assumed to arise from the implementation of ITS raising and lowering the projected demand for workers from current expectations of future supply of them.

In total, over 40 stakeholders were consulted at the workshops or in person to elicit their views. The stakeholders' backgrounds included: automotive engineering; vehicle sales; human resources; freight; professional engineering; industry training; business associations; professional associations; and consumer groups. In addition to these, stakeholders from central and local government organisations for policy and operations were present. Stakeholders from academic fields, including ICT and engineering, were also represented.

Stakeholders developed their views on themes and issues in small groups. We present the learnings from the workshops here, together with learnings from questionnaires to diverse stakeholders and some one-on-one interviews, where the responses were analysed prior to the workshops and helped frame the themes and issues for them.

In developing these findings we sought to include views that:

- represent recurring themes across the groups and workshops
- resonate with views expressed in the global literature and media
- contain unique and valuable insights from actual experience in New Zealand
- are reasonable to the authors from their respective areas of expertise.

The skills gap assessment presented is outlined in terms of two of the five ITS technology scenarios at 2035 for New Zealand, from chapter 2. These two extreme scenarios are:

- scenario 1 – slow progress path
- scenario 4 – rapid progress path.

In selecting only two, we omit the mixed rapid and slow uptake scenario, which is a composite of the two extremes presented. We also omit the two medium uptake scenarios (with and without policy incentives).

The medium scenario can be inferred as being an intermediate between the two scenarios presented. The impact of public policy generally for ITS is a topic that we discuss separately below.

The nature of the ITS technologies and the underpinning reasons for their likely presence has been outlined in chapter 3.

## 6.2 Framework for assessment

To develop this skills gap assessment, we assumed present occupations and skills as a starting point and then assessed the likely skills needs consequent on the state of ITS technologies in 2035. Before we present this assessment, we describe the development of a framework for this assessment. This framework accounts for:

- occupation as a basket of skills
- evolutionary change in skills demanded
- varied range of skills including generic, specific, codified, tacit, STEM and human-centric.

### 6.2.1 Occupation is a basket of skills

Technology change causes changes in the demand for particular tasks. An occupation is usefully seen as a basket of specific skills and generic skills. This is consistent with the discussion of Litman (2017) in chapter 2, where for example bank tellers are seen as possessing a collection of tasks, where only some of the specific tasks are substitutable by ATM technology. This means there is still a demand for the occupations of bank tellers, although with a different mix of tasks and in a smaller number for a given level of economic activity. Indeed, using the discussion of Acemoglu and Restrepo (2016), in chapter 2, the mix of tasks that comprise an occupation affected by a technology change can also change to include new ones made possible by the technological change. For example, a driver, whose occupation consists of driving, together with several other tasks, including itinerary selection, customer service and moving objects, may still be required to be a driver where semi-autonomous vehicles are prevalent. This is because, while the task of driving may be less than before, all the other associated tasks that comprise the occupation are still present. Indeed there may be new high technology tasks for drivers in an ITS environment, such as platooning other vehicles.

### 6.2.2 Skills change is evolutionary

New skills will not immediately and totally replace the demand for current tasks required for an occupation. This is because the impact of technological change tends to be evolutionary, rather than revolutionary. This accords with the concept of the S-curve for technological change, which is influenced by the availability of new technologies and the capacity and preferences of people to support technology take up. This availability, implementation and take up will occur at different rates for different circumstances.

Hence, over time there will be a gradual change in new skills required for relevant occupations. Alternatively, these skills may be possessed by specialists working alongside workers with existing skills. Importantly, for this study, there will continue to be a demand for prevailing skills. The pace of change will be determined by the pace of implementation of ITS which is itself determined by the pace of change of connected mobility.

In extreme cases, where there is a change in almost all tasks of an occupation, the occupation itself will cease to exist in its current form and a new occupation is created. These cases are outlined by Acemoglu and Restrepo (2016) as discussed in chapter 2. In the case when only some tasks change, the qualifications required for an occupation are also likely to change.

### 6.2.3 The basket of skills is varied

We can think of qualifications generally as encompassing a wide set of training, because skills are acquired through formal and informal training. Formal training tends to be codified and prescribed in texts and procedures. Informal training, such as on-the-job learning, tends to be tacit and learned through trial and error with mentoring.

In addition to being a mix of codified and tacit training, a qualification also contains generic and specific elements. Generic elements are common to many skills and therefore to many occupations. For example, application of geometry is generic to civil construction and to basket weaving. Specific elements are uniquely important to specific professions. For example, thermodynamic models of heat dissipation are specific to certain parts of automobile design and to certain types of transport engineering and not to others. A change in technology such as ITS can mean that different skills that are demanded in a greater or lesser degree, may be either generic or specific.

Overall, the incremental qualification needs following ITS implementation may require small or large changes to qualifications, in terms of whether the skills they target are:

- demanded in a greater or lesser degree
- codified or tacit
- generic or specific.

The TSC (2016) study indicated the wide range of skills required in a new ITS environment. Importantly, there is likely to be a shift in emphasis towards human-centric skills relative to STEM skills.

### 6.2.4 Occupation-based framework

The skills gap assessment presented in this chapter is set out in terms of occupations because:

- Occupations are well defined and well understood (eg assigned specific codes by statistical agencies).
- Skills are contained within this well-defined set of occupations and this forms a sensible base for analysis.
- Skills are generally expected to change gradually and so the stable base of current occupations will be a robust basis for discussion of change in skills from the present to the future. That is, in general, there will not be a sudden change that requires entirely new skills to the extent that the occupation itself changes.
- Stakeholders articulate skills gaps in terms of skills possessed by current occupations. They do not conceptualise an entirely new occupation. They are more inclined to say that drivers and automotive technicians will require new skills, rather than there is a need to define new occupations to replace these two.
- Occupations are also linked to qualifications. Qualifications change gradually to meet changing needs of occupation. If only partial and gradual changes to skills are required, it is reasonable to assume that tertiary institutions, training organisations and in house training will also undergo gradual changes in content.

Our occupation categories extend from the individual to the cloud (in the computing sense):

- sales and inspectors – individual people who approve and release the vehicles
- drivers – individual people who drive the vehicles
- automotive technicians – people who maintain the vehicles
- engineers – people who provide the roads and manage and maintain them
- ICT personnel – people who provide the analytics, connectivity and big data in the cloud.

The skills changes for ITS implementation (as exemplified by the TSC (2016) study are widely agreed to involve both:

- changes in skills related to the technology itself, such as STEM skills
- introduction of human-centric skills, such as from social science and creative disciplines.

Hence, our framework for assessment of skills changes is made in terms of occupations, within which we assess skills changes due to ITS technology change, together with the pace of change as well as the emphasis on STEM and social science and creative disciplines.

## 6.3 Public policy

Implementation of ITS is widely reported to provide many benefits to society including:

- lower cost of mobility
- lower congestion of roads, thereby enhancing timeliness of travel
- safer roads with less human error
- more efficient consumption of road pavements, thereby requiring less road maintenance
- increased availability of mobility, particularly for older persons and the disabled
- greater access to diverse services.

For many reasons, including these, the government (central or local) may implement policies to support ITS infrastructure and availability of autonomous vehicles with targeted policy instruments. Such policies may also include enabling policies to manage risks related to privacy, security and fraud.

Such enabling policies will lower many of the barriers to participation by public agencies, businesses and households in an ITS environment. Consequently, such policies will have a corresponding influence on the demand for occupations discussed in the following sections and must be included when considering the impact of ITS on demand for occupations and their skills mixes.

## 6.4 Sales people and inspectors

### 6.4.1 Inspectors

Motor vehicle inspectors who work for service delivery providers of the Transport Agency, such as VTNZ, have skill sets that differ from automotive technicians in one very important respect. They are compliance oriented and therefore their skills tend to emphasise theoretical/hypothetical cases and so their skills are more codified than the skills of auto mechanics.

In a rapid progress scenario for vehicles, vehicle inspection is likely to become much more complex. Although this might suggest a need for inspectors to be highly skilled, this burden could be overcome by technology. In this case the inspector would be likely to access online assessment tools, potentially connected to original equipment manufacturer (OEM) databases. In this way the inspectors will outsource the assessment skills. At the same time, there will be a need for inspectors to have a high degree of pragmatism in their assessments, particularly because the connection between safety and component malfunction will not be well tested. This is a tacit skill that can be developed gradually through on the job training. Importantly, demand for these tacitly trained inspectors will be driven by consumer demand for their respective vehicles.

### 6.4.2 Sales

Sales people can now study towards a nationally recognised qualification, as discussed in chapter 7. However, motor vehicle sales personnel currently require no accreditation. Transactions are governed by the Fair Trading Act 1986, the Sale of Goods Act 1908 and the Consumer Guarantees Act 1993. In these, the rights of the consumer are supported largely because consumers have less information about the goods and services they purchase than vendors. There is an increasing role for sales people to access and communicate on-line and for real-time information. Sales people may not need special skills to access such information as the type of skill required is generic to many sales occupations and potentially may be acquired through on the job training. However, a crucial part of the role of sales people is communicating information regarding goods and services that are often complex, while subject to a regime of consumer and credit laws. Potentially, with the increase in complex information that ITS implementation will bring, sales people may need new skills to work with such information under the legislative regime.

## 6.5 Commercial drivers

In slow progress scenario 1, the current demand for drivers will not lessen, particularly for heavy freight drivers. At present, there is a shortage of heavy freight drivers. While the barrier to entering this occupation is certification as a driver, there is considerable tacit knowledge required in experience in managing freight loads, apart from the actual driving. This tacit knowledge can be obtained through on-the-job training which is required, rather than any change in qualification.

Under rapid progress scenario 4, businesses are expected to rapidly exploit the profit opportunities from autonomous vehicles. The Morgan Stanley (2015) report indicates that autonomous and semi-autonomous driving technology will be adopted far faster in freight markets than in passenger markets because humans are far more comfortable with autonomous technology operating vehicles in circumstances when human life is not at risk.

Freight operators will be motivated to deploy autonomous platoons that can operate 24 hours a day with much less labour. The vehicles can be in semi-autonomous mode when in the platoon. As technology improves, a driver may sit in each vehicle, in only the lead vehicle, or eventually in none of the vehicles.

In rapid progress scenario 4, semi-autonomous platoons controlled by a lead driver may operate in some circumstances. There is still a need for drivers, but the number demanded may decline if freight volume is unchanged from that otherwise. However, freight volume may increase relative to the baseline scenario due to higher productivity of haulage through lower labour costs. Freight volume will also increase in the baseline scenario due to population growth and economic growth. In a platooning environment there will also be a need for programmers, route planners, maintenance experts, fleet managers – some of these tasks may be assumed by drivers. Potentially, the human driver may need to be proficient in certain technologies that could require a higher education level as well as technical certifications. Some human oversight will be necessary for attending to breakdowns and issues of safety and security of inventory.

In rapid progress scenario 4, there is also likely to be a fall in demand for certain types of drivers. For example, if public transport and platooning of private and commercial vehicles in dedicated lanes displace use of existing modes of transport, then fewer bus, commercial and taxi drivers may be required.

Autonomous passenger transport has particularly important application in low-speed uncontrolled or high-speed controlled areas. In addition, the potential for connected journeys of passengers will reduce the demand for public transport to and from other transport modes. As we noted in chapter 3, the ITF (2016) has described many urban and suburban applications. These include passenger shuttles and taxis that might operate at low speeds in central business districts, corporate campuses, university campuses, military bases, retirement communities, resorts, shopping centres, airports and other semi closed environments, as well as for first and last-mile public transport applications. Delivery shuttles might likewise travel at low speeds along particular routes and at particular times.

## 6.6 Personal drivers

The demand for driver occupations will also be influenced by household demand for semi-autonomous public transport and also platooning of private vehicles. In both cases, human driven vehicles such as taxis, buses and shuttle vans may be displaced. Driver demand will also be influenced by household preferences to connect the vehicles in which they travel with other vehicles. Overall, these influences may increase or decrease the demand for autonomous vehicles. However, the prime influencer of demand for vehicles, which will impact on the quantity of skilled workers, will be the successful uptake of fully autonomous vehicles. This will be determined by the demand of households for safe, reliable and timely transport and demand for personal privacy.

Vehicles can be connected by platooning through the control of a driver. V2V and V2I connection can be achieved with embedded telematics or with nomadic telematics devices such as smartphones. The propensity for individuals to connect to other vehicles with V2V technologies may be constrained by their preferences for privacy and security. Consumer preferences will play a large part in determining when and where consumers may wish to have CVs.

## 6.7 Traffic police

Importantly, there are at present no laws prohibiting AVs in New Zealand. There are penalties for dangerous and reckless driving. Police may prevent driving of unsafe vehicles. Traffic police will still have the same occupations but their skill sets will need to include assessment of dangerous and reckless driving in driverless situations. Specific legislation or regulations covering this area may be necessary to guide the police and to provide certainty and security to the public. Defining the practice will be business as usual for legal personnel. There will be a need for marketing personnel to develop public awareness. Specific skills for traffic police to implement this practice and to demobilise and control driverless cars may require some specific new skills that can be learned as part of their training and would not substantially differ from their current skill sets.

## 6.8 Automotive technicians

There is currently a shortage of trained automotive technicians; an expert estimate is a shortage of 2,000 automotive technicians, nationally (see box set 3).

This shortage needs to be addressed immediately, otherwise skills gaps will be considerably increased in a high-technology ITS environment. This may lead to safety issues from lack of skilled people to maintain high-technology vehicles.

In slow progress scenario 1, there is an increase in demand for high technology automotive technicians, brought on by the emergence of high-technology vehicles, including electric vehicles. The skills often involve use of computers to diagnose automotive malfunction. With electric vehicles, new skills for handling high-voltage vehicles are required. Both computer and electric engine skills are codified and their need is prompting industry training organisations to change the content of qualification courses. Hence the occupation remains the same, although the skills content is changing. This is an example of where technological change requires new skills within an existing occupation. Automotive mechanics in this case are still in demand, but are required to have more complex skills. The need to upskill staff may place pressure on small businesses and this may lead to a trend where larger businesses dominate the new high-technology areas.

**Box set 3 The Motor Trade Association (MTA) welcomes investment in apprenticeship training (Source: Automotive Employment New Zealand 2016)**

MTA is welcoming the government's announcement today of two tranches of additional investment in apprenticeship training – one for general training and one for Māori and Pasifika Trades Training (MPTT).

MTA Acting Chief Executive Craig Pomare said MTA understands there could be as many as 2,000 vacancies for qualified automotive technicians nationwide.

'Many general repair MTA workshops could easily employ another one or two mechanics but there are none available. Some businesses are able to employ overseas qualified mechanics but it would be great to build up the number of Kiwi trained apprentices,' he said.

Demographically, the industry as a whole is predominantly NZ European. MTA is keen to see the industry reflect the diverse make-up of the New Zealand population. Resources to increase the number of Māori and Pasifika apprentices is welcome.

The government has promised an additional $14.4m over four years for more apprenticeship training across all trades, and $9.6m for MPTT also over four years.

In rapid progress scenario 4, there will be a rapid increase in both the skill level of the occupation and its specialisation if automotive technicians need to maintain complex high technology devices connected to internal combustion power trains of different brands. If so, there would need to be a substantial change in the codified skill content, leading to a substantial change in the qualification. There will also be a greater demand for specific skills developed on the job, where automotive technicians specialise in the technologies unique to specific brands.

However if, in this scenario, automotive technicians are limited to recording diagnostic data, which is then analysed remotely, then the essential role of the automotive technician in maintaining an internal combustion power train remains unchanged, as would the qualification required. In this case the automotive technician would refer the diagnostics to other skilled people, such as ICT technicians, electronic engineers and other specialists. In some cases the referred specialist may be offshore, such as OEMs, but need not necessarily be so. In this case the new vehicle technology has created a new demand for high-technology skills that does not displace the existing automotive technician occupation, but complements it. An analogous situation already exists where automotive technicians currently refer to specialists – such as alloy wheel installers – to perform specialist tasks. This situation is also common in other professions, such as where medical GPs diagnose patients generally and then refer them to specialists for targeted treatment.

At the same time, there may be significant barriers for automotive repair firms to access offshore OEM diagnostic databases. This access issue, motivated by the desire of OEMs to withhold proprietary information, has been addressed to some extent by recent EU standards requiring a specific level of access. However, it is unclear whether and to what extent EU standards will apply to New Zealand. In addition, it is likely that smaller firms, including rurally based ones may not have the resources to secure access and this would mean that the capacity of such firms to provide services and the demand of skilled automotive technicians in them may decline.

This out-sourcing arrangement and the issue of barriers to accessing information similarly apply in the case of maintenance of electric vehicles.

The automotive technician may need some training to enable them to interact with specialists at the right ‘entry point’ for the specialists and this specific codified skill could be included in the existing qualification. Potentially such skills could be included in the industry training organisation and industry training provider apprenticeship training. In some cases, there may be a role for this codified training to become part of the on-the-job learning of franchised motor vehicle repairers, who specialise in particular brands.

Alternatively and in addition, auto mechanic apprentices may receive training either locally or offshore from trainers accredited by OEMs of individual brands. This already happens for the maintenance of certain franchises of motor vehicles.

Importantly, as automotive technician training becomes more specialised, such as where skills are specific to a particular car brand (eg Ford, Toyota), their skills become less transferrable to other car brands. As cars with higher levels of technology are introduced, the barriers to skill transfer between businesses will increase. This will exacerbate skill shortages because, even with increases in wages to workers, specific skills cannot be acquired easily and quickly.

Even under a scenario of fully autonomous vehicles, which are likely to be different from semi-autonomous vehicles in many respects (since human interfaces such as steering wheels, windows, headlights, etc are no longer required), the power train will continue to be internal combustion or electric. Hence most of the basic skill sets that comprise the occupation of the automotive technician are likely to remain in demand, with a new demand for skills that interface the motor mechanic with outsourced specialists and information.

For fully electric vehicles, there is likely to be a substantial change in the skill set required by automotive technicians, who have a skill set that is fundamentally different from that of internal combustion mechanics. This would likely require a specific codified qualification for electric vehicle automotive technicians, because the electric power train is so different from the internal combustion power train. Interestingly, although both types of training are geared towards increasing complexity of power trains, the electric automotive technician may require different training from other automotive technicians. Given the anticipated growth of electric power trains, this would be an example of where ITS technology will displace the internal combustion automotive technician occupation with a differently skilled electric one.

It is a widely held view that AVs will, in the long-run, yield many safety benefits, particularly in the form of fewer road collisions. In the very long run, therefore, automotive body repairers are expected to face a decline in demand relative to automotive technicians. However, with only part of the vehicle fleet comprising semi-autonomous vehicles by 2035, the skills of automotive body repairers are likely to continue to be in strong demand at that time.

## 6.9 Engineers – professional and technical

Under the slow progress scenario 1, there is a shortage of engineers with policy and planning expertise as agencies and organisations create business plans and strategies for the forthcoming implementation of ITS. In some cases current engineering-related occupations possess these skills. However, the skills are largely codified since they are believed to involve business planning expertise together with an understanding of the interface of transport management as a system. For this reason, some organisations may source these skills from non-engineering occupations, including traditional business analysts. There is also a demand for an outcomes focus in the skills required, consistent with the planning function. To some extent this is a tacit skill, where outcomes are unique to a given policy domain and some on-the-job learning is usually required to embed them.

At present, future demand for new skills is being signalled, but as yet there is only limited demand for new qualifications or for new training requirements or a variation of existing qualifications. The need is likely being met from employing specialist transport engineers (including migrants) with these skills or from sourcing the requisite skills from non-engineering occupations. In the longer term, one solution to the skills gaps is likely to involve transport engineers collaborating and working alongside business planning specialists in a multidisciplinary team. For this reason, full proficiency of engineers in business planning skills may not be required, but only a capacity to interact with specialists. This skill can be acquired through professional training courses.

In rapid progress scenario 4, there is limited fully autonomous driving in well-defined domains, such as dedicated lanes in highways. In addition, electric vehicles will become a significant part of the national vehicle fleet.

Importantly, most of the ITS technologies to be introduced will likely involve a continuous and increasingly human-centric emphasis on the consumer and the vehicle. This emphasis will treat them together as an individual asset which:

- generates revenue according to road use
- provides real-time information through telematics
- consumes digital services.

Consequently, by 2035, there is likely to be a greater demand in transport planning and management occupations for human-centric skills such as from the social sciences and creative disciplines. Such human-centric skills include ethics, critical thinking, human behaviour prediction, human machine interfaces and decision making.

Urban and metropolitan areas will provide demand for ITS infrastructure and associated personnel including ICT specialists, civil engineers, transport planners and engineers and traffic technicians who will be required to work in collaborative multidisciplinary teams, outlined above, to manage and maintain the transport network in real time.

Perhaps the most important catalyst that infrastructure can provide for ITS implementation and therefore for demand for skills, is the establishment of operational design domains such as dedicated traffic lanes for fully and near fully autonomous vehicles. Planning and construction of such lanes will likely be similar to establishment of bus lanes with no extra skills required.

In rapid progress scenario 4, skills of engineers and ICT personnel, both professional and technical would be in demand to construct, manage and maintain dedicated lanes. As an indication of the codified skills required, we can look at the expected technology of the high technology scenarios. The Morgan Stanley report (2015) indicates that in those scenarios there will be: 'side lanes' where 'autonomous vehicles can pull out in case of technical issues; fully networked intersections and traffic monitoring capability; fully mapped roads with real-time updates; and massive network capability to handle the data needs'. According to the ITF (2015) physical infrastructure requirements might include V2V and V2I communications equipment, ground-based units for global navigation systems, dedicated facilities comparable to bus and bicycle lanes, on-street parking restrictions and specific roadway or pavement modifications.

The presence of motorway environments and other high-volume roads supports dedicated lanes and this may influence the volume of skill sets required, as noted by the ITF (2016) report. Dedicated lane facilities will likely require expensive retrofitting on existing roads and so be viable only on new roads and high-volume roads.

With the advent of big data analytics under rapid progress scenario 4, the analysis of traffic management systems, their subsequent design and maintenance can be streamlined. This includes through the application of M2M technologies which will transform diagnostic data into readily accessible information for traffic management systems. This will create less demand for traffic engineering professionals currently involved in analysing traffic problems using data collected from smart roads and providing solutions. Data analytics are also expected to result in more efficient use and monitoring of road pavements, so less civil construction for road maintenance is possible. The lesser demand for professional engineers is likely to offset, in part, the greater demand for them for road infrastructure occupations.

Telematics as discussed in chapter 3, is an important technology where people and vehicles act as sensors. A nomadic device, such as a smartphone or a SIM card together with connective technology embedded in a vehicle, can provide relevant information on identify, location, speed, time, traffic congestion, predictability of travel direction, etc. This approach would lessen the demand and cost for built high-technology infrastructure (such as embedded sensors) and for the skilled people to put it in place.

Rapid progress scenario 4 will require a new conceptualisation of society's transport needs and its impacts for any future infrastructure asset. The skills required for this concept building will be sourced from multidisciplinary teams of: economists, future scenario planners, business analysts, systems analysts, traffic engineers, systems engineers and ICT professionals. Initially, where these skills are not available in conventional transport management teams, they are likely to be outsourced to local and offshore consultants. In addition, teams can be formed using specialists from other industries, such as for sourcing business analysts from the banking industry. The skills required are highly codified but also contain significant tacit knowledge. Hence they are unlikely to be currently possessed by transport planners, nor are they likely to be obtained from on-the-job learning.

Under many of the ITS progress scenarios, there will also be a move away in traffic management from the management of hard assets to a more strategic approach where multiple traffic systems are integrated to deliver services to customers. There will be a need for skills able to consider the interconnection of multimodal transport and provide solutions in an evolutionary way.

There will be a need for skills to develop future scenarios and to assess their merits and shortcomings. Importantly, the pace of development of infrastructure will depend in some way on the level of take up of AVs. Hence some risk management skills are also required to assess the financial risk of investment in built infrastructure that may quickly become obsolete from further technological change.

The foregoing skills gap assessment applies primarily to public transport agencies, but not at the exclusion of private sector organisations which must also operate and collaborate in the new environment.

## 6.10 ICT personnel

Under many of the ITS progress scenarios, skills will likely be required for the following areas and will be in high demand for rapid progress:

- preparing diagnostics of vehicle and infrastructure performance and providing this to offshore analytic services
- providing diagnostic (big data) solutions for local use and for offshore customers
- providing global (cloud) solutions to analyse diagnostics from data sent from vehicles and infrastructure
- cybersecurity
- running and maintaining local M2M analysis programmes
- designing human-centric interfaces for vehicles and infrastructure for local use and for offshore customers, particularly for MaaS solutions (eg connected modes of mobility, where mobility is provided as a service to substitute for personal mobility options)
- providing infotainment products for local consumption.

As noted by the TSC (2016) report, the impact of data analytics for transport will be very significant. This is particularly important because data analytics is not a historic focus of traditional transport engineering paths. Equally, it is not a traditional focus of other skills areas.

In some cases the codified skills required are located offshore or possessed by specialists. In this case, there will be a demand for these specialists (eg data diagnostics), and the non-specialist (such as the automotive technician) can out-source the skills demanded. However, in many cases the role of data analytics is an integral part of the skills needs of the transport system. In these cases, workers in conventional occupations need to acquire these codified skills, such as through training, or to acquire a minimum level of skills to enable them to actively collaborate with the specialists in multidisciplinary teams.

Demand for data science skills is expected to increase in an evolutionary way. Initially, the need for big data analysis from existing traffic management systems and improvements of them, will prevail. This can proceed with current technology such as with offshore data analytics, accessed through cloud computing, and connecting to analytic tools with the IoT, in real time. ICT professionals and technicians are likely to need to manage and maintain the offshore connections, as is the case in the meteorological sector, for example, with current real-time meteorological and climate information.

As M2M solutions are implemented globally, there will be local adoption of them, which will streamline data analytics. Part of this will involve using people and their nomadic devices (eg smartphones) as identifying sensors, such as for toll pricing management. This will also streamline data collection and analytics. In this context, the role of the ICT professional in transport is itself likely to evolve from a data analysis role to one involving collaboration as an 'algorithm specialist' working in collaboration with other professionals. Alongside the ICT professional, there will be a corresponding increase in demand for ICT technicians to run and maintain software and systems. The training for this may be sourced offshore and possibly provided by OEM providers of the M2M technology.

Demand for ICT professionals and technicians will be strongly supported by the significant opportunities for New Zealand firms to provide bespoke information solutions locally and globally. This is not solely an ICT task. It will require a view of traffic management solutions as a system-wide set of activities, only some of which are ICT-related. It will involve a combination of activities including:

- business case assessment of outcomes and outputs required
- hardware design and interface with traffic infrastructure

- development by ICT professionals of smart algorithms to achieve the outputs and ultimately the outcomes.

There is also the potential for ICT professionals to access the global IoT to provide local solutions with big data networks. New Zealand firms are already developing such smart solutions in other industries. One example is the FruitSenz (2017) information solution. The extension and expansion of this type of business activity to the transport sector seems quite plausible.

MaaS has a huge potential for increasing business opportunities. This could result in a greater demand for diverse services in areas such as hospitality, health, social services and security made less expensive due to the decreased cost of transport from location of provider to consumer. Coupled with the actual services are the opportunities for supporting industries for creating public awareness of the services through marketing and for creating on-line access (such as with apps). This indicates a huge potential for software designers and market research personnel, and therefore would increase the demand for their specific skills.

In this context, providers of cellular networks will require ICT professionals and technicians to establish, manage and maintain the new cloud computing environment.

The implementation of driverless cars will provide opportunities for MaaS services, but will also create free time for passengers who would otherwise be driving. The emergence of new services and new time will provide an opportunity for a new infotainment industry. Essentially this amounts to information and entertainment for people to effectively utilise during their time as a passenger. The Morgan Stanley report considers this new industry having huge potential.

This has at least two implications for the future demand for skills of ICT professional and technicians. Software solutions will be needed to connect to embedded telematics in vehicles and provide local information and entertainment solutions. Hence there will be substantial scope for creativity and design. In addition, the software solutions will need to be human-centric. This is more than being user friendly and involves creating a solution that becomes as important, if not more important, than the travelling experience. Similar to the case of bespoke traffic management solutions, (above), the effective provision of solutions will require a collaboration of:

- business analysts who can assess the consumer preference and define it
- electronics engineers who can provide the hardware solution
- ICT professionals who can design and maintain the algorithms to provide the solutions.

In addition, in the case of infotainment, there also needs to be included the collaboration of design and marketing specialists who can ensure the solution meets consumer preferences.

## 6.11 Conclusions

A deficit in the supply of skilled workers, to match new areas of demand associated with the implementation of ITS, is expected by 2035, assuming current trajectories of supply continue.

It is in the context of two of our five scenarios, namely those for slow and rapid uptake of ITS, that we assess skills gaps. By 2035, we expect ITS implementation to be partial across various locations with a variety of semi-autonomous vehicles. Fully autonomous vehicles will be available in controlled environments. Government policy to enable and facilitate uptake of ITS to 2035, will influence the level and scale of ITS take up.

In summary, our qualitative skills gaps assessment is that:

- Current occupations will likely still be in demand, but skills required of them will change significantly.
- All occupations will require skills to access and operate,on-line tools and on-line resources, though with the development of the IoT, such skills may be ubiquitous by 2035.
- Commercial freight drivers and passenger transport drivers will likely require new skills to operate near-autonomous vehicles in controlled environments.
- Automotive technicians will require new skills to maintain complex high-technology devices in vehicles. Some of these skills may be specific to particular brands and models. They will likely need to operate computer-based diagnostic equipment and interact with specialists locally and on-line.
- Professional and technical engineers will need new skills to enable their collaboration in multidisciplinary teams with others from diverse disciplines to provide user friendly and people-focused transport solutions. They will need skills for addressing transport environments as systems involving people, infrastructure and connected mobility outcomes. They will require human-centric skills to complement their STEM-based skills.
- ICT professionals and technicians, like engineers, will need collaborative and human-centric skills. Data analytic skills will be in high demand, but coupled with skills for creativity and design. In addition, skills will be in high demand to create new solutions for people, and to provide connectivity of embedded telematics in vehicles with other devices, cellular networks and the cloud.

# 7 Assessment of future training needs for New Zealand

## 7.1 Introduction

This chapter provides an assessment informed by stakeholders of options for future training needs to address the future skills gaps expected under the implementation of ITS to 2035. Basically, the projections are for five-yearly intervals up to 2035. We noted in chapter 2 that qualification changes were consequent on changes in skills demanded. The expected skills gaps, leading to qualification changes and to changes in training needs, were discussed in chapter 6. In that discussion we noted that skills changes, like technology changes are likely to be evolutionary. This suggests a gradual change in skills and therefore in occupations and qualifications and training needs. Hence our assessment of future training needs is expressed as an incremental change from qualifications as currently defined.

## 7.2 Public awareness

There is a widely held view that the general public needs to be better informed about future ITS technologies. This implies a need to train communicators and media people to enable them to inform the public about ITS and transport planning. Consumers who purchase vehicles will need to be aware of the benefits and risks and their liability of operating semi-autonomous vehicles. Such training can potentially be provided through digital media. More complex training will be required to enable users to competently operate semi-autonomous vehicles. It is unlikely to be the responsibility of the manufacturer or the vendor. For public policy reasons the government may have a role to support training organisations to provide such training.

## 7.3 Current skills shortages in ITS-related occupations

At present there are chronic shortages of skilled professional engineers, automotive technicians, ICT professionals and technicians, and commercial drivers. These occupations are all relevant to the future ITS environment. This chapter outlines why they emerged over the past decades, and discusses initiatives in place to address some of them. For all these skills shortages, inward migration is widely recognised as an important source of future supply of skills. Quantitative projections we provide in chapter 8 are based on Statistics New Zealand’s median population projections to 2068, basis 2016 (Statistics New Zealand 2016). These assume annual net inward migration of 60,000 in 2017 decreasing by 9,000 annually to 15,000 in 2022 and beyond.

## 7.4 Transport professionals

Transport professionals in both private and public sector organisations see a need for a wide set of skills in future transport planning, implementation and operations.

### 7.4.1 Scope of training

The implementation of ITS will involve the introduction of new technologies and their maintenance and servicing. The whole transportation sector will change. Consequently, to 2035, there will be a need for transport professionals to understand transport as a system of actors and technologies that will be in a state of change. In order to function in this change environment, transport professionals need to be trained in a way that makes them proficient to 'learn fast and fail fast'. Failing fast is an important precursor to the next learning step.

The wider codified learning from tertiary institutions in areas such as resource management, urban planning and public policy, is not necessarily part of traditional professional engineering courses at universities. Such skills will be required to complement STEM training so as to provide resilience to organisations for sustaining technological change under ITS implementation. Taking a systems view is important for future-proofing critical infrastructure in the long-term plans of organisations.

The future transport professional may possess these skills in some depth personally and be an expert in a selected field. Alternatively, they may possess sufficient skills to enable them to interact with people with these skills. Consequently, the role of the future transport professional can be seen as both specific to certain areas as well as a flexible collaborator who can interact with others both locally and offshore.

### 7.4.2 Collaboration

The capacity to collaborate and interact is especially important, because the introduction of new technologies will require local professionals to connect with international knowledge bases, technical groups and policy forums. For example, Auckland City is part of a C40 (2017) global network of city administrators that seek to collaborate and learn through interactions to provide best practice planning. In order to participate effectively in this type of global learning network, policy professionals need to have the capacity to participate and collaborate by having a wide codified knowledge base, and have the capacity to interact in multidisciplinary teams.

### 7.4.3 Continuous learning

There are many different ways this kind of broad-based learning can be acquired. Importantly, in the context of fast-moving technological change, it is believed that a continuous learning process is necessary. Training needs to be flexible, while focused and timely in order to maintain its relevance. In an ITS environment which is likely to experience continuous change for many decades, it is desirable to provide re-training for existing professionals, so that learning becomes a life-long process.

Training can be difficult for firms to provide, since they are business oriented and not training institutions. It is especially difficult for small firms to provide training. Universities provide degree-based qualifications based on successive stages of codified knowledge. While they can adapt some of the degree-based content to provide some of the new codified knowledge required they are not best suited to provide a wide-based learning programme.

In addition to the codified knowledge, there is a great deal of tacit knowledge, learned in the workplace in interactions with others that transport professionals will acquire. This needs to be assessed and validated for it to be useful.

### 7.4.4 Professional apprenticeship

One option for future training is a professional apprenticeship programme, where the content of the degree-based courses is wider to encompass new skill areas and students spend time employed on site with transport professionals to develop tacit knowledge. Potentially, such a programme can involve many different work environments, including policy, planning, operations, monitoring, analysis and community services. This kind of programme would need to be managed by a professional institute such as the Institute of Professional Engineers New Zealand (IPENZ) and would require the collaboration of tertiary institutes and public and private sector organisations. Public sector road controlling authorities would be likely to play an important role in the governance of such a programme.

### 7.4.5 Flexible credentials

One option to widen the scope of codified learning at universities is to make established codified learning programmes more flexible. Potentially, with cross-faculty cooperation, the content of degree courses can be sourced more widely from different disciplines. The challenge to universities is to maintain the quality and the validity of the knowledge that is learned. The provision of training modules that are focused in relevant content, where the content can be quickly updated, is one way to provide flexibility. However, such training can often become ad hoc and under-valued by employers if they are not part of a qualification. Hence, such flexible training solutions need to be embodied in a career pathway where the value of the flexible training is clear and the achievement of learning is recognised in a qualification.

In addition to across-faculty collaboration, training can become more flexible by recognition of modules of training with credential such as micro-credentials (see box below).

**Box set 4 Micro-credentials now being trialled in New Zealand (Source: Corner 2016)**

Tertiary education, skills and employment minister, Paul Goldsmith, has announced New Zealand's first trial of micro-credential courses, including a course in self-driving car engineering programme delivered online by Udacity.

Micro-credentials, also known as badges and nanodegrees, allow for specific skills or components of learning to be recognised. They are not units of learning toward a full qualification, but are a recognition of specific skills, experience and knowledge.

According to the Ministry of Education, 'Examples of micro-credentials include short courses delivered online, in the workplace or at training institutions. Micro-credentials can be at any level of a qualifications framework and would typically be between 5 and 60 credits.'

Udacity's Self-Driving Car Engineer nanodegree has been assessed by the New Zealand Qualifications Authority (NZQA) as equivalent to a 60 credit package of learning at level 9 (Masters level) on the New Zealand Qualification's Framework (NZQF). It covers deep learning, computer vision, sensor fusion, controllers, and related automotive hardware skills and takes nine months of part-time study.

Goldsmith said it was one of three micro-credential pilots in the Government's work programme introduced in response to the Productivity Commission report on tertiary education. NZQA is working with Otago Polytechnic and the Young Enterprise Scheme on the other two.

The three pilots will be evaluated by NZQA within six months with a view of considering how best to support the further development of a micro credentials system in New Zealand.

'These new pilots reflect this Government's commitment to driving forward the kind of innovation in the tertiary education system recommended by the Productivity Commission's report,' he said.

Goldsmith said micro-credentials would help New Zealand's qualification system adapt to meet evolving skills needs. 'Learners and employers will always value formal qualifications, but as workers need specific new skills across their lifetime, a micro-credential may be an excellent option for learners to upskill without completing a full formal qualification,' he said.

Otago Polytechnic launched its micro-credential service, EduBits on 27 July. It recognises sets of skills and knowledge to enable just-in-time workforce upskilling and reskilling and is being developed in conjunction with industry. Otago Polytechnic and NZQA will jointly award micro-credential EduBits as equivalent to five to 60 credits across the levels of the NZQF.

One option suggested by the US PCB programme discussions (see section 4.3.2) is to use technical colleges to provide this wider knowledge base. This could be achieved by degree qualified students, taking subsequent courses at industry training providers. Such a programme could be set with a wider continuous learning programme and supported by tertiary institutions, government and industry.

There is a role for large multinationals that provide ITS technology to provide training courses, in a similar way to that already provided by software training organisation. Alternatively, they can provide the content and the training can be provided by accredited organisations.

### 7.4.6 Skills shortages

There is a shortage of professional engineers in New Zealand (Engineering e2e 2014) that is also attributable, in large part, to the low number of students enrolling in engineering courses.

This shortage is especially seen for civil engineers and automotive engineers (Edmunds 2016) where from 2005 to 2014, civil engineering, which is currently on the government's skill shortage list (Immigration New Zealand 2017) lost 25% of its students, while automotive engineering dropped 40%.

As shown elsewhere in this report, these two professions will provide significant sources of skilled labour in future ITS relevant occupations. As with ICT professionals, short-term needs are being addressed, in part, from skilled migrants (Immigration New Zealand 2017). However, like the ICT skills shortage, the problems are systemic and they present a significant downside risk to future supply of engineering professionals in ITS-related occupations.

IPENZ identified a number of issues in 2007, which, similar to the ICT profession, have contributed to the long-term shortage of professional engineers.

These issues (Engineering e2e 2014) include:

- a lack of clarity about pathways from school to engineering education and a lack of consistency in entry requirements
- unclear career pathways, particularly in regard to level 6 New Zealand Diploma in Engineering and level 7 Bachelor of Engineering Technology qualifications
- difficulty in some tertiary institutions maintaining sufficient students to adequately cover specialist areas within the programme
- insufficient coordination between disciplines and qualification levels for a national network of provision across all provider institutions.

Underlying these issues are a number of significant challenges to encouraging more students to study engineering at institutes of technology and polytechnics (ITPs), including:

- there is little understanding of what a career in engineering means
- engineering is perceived as an unattractive career
- barriers to studying engineering are perceived as high; they occur early and are compounded during the progression through school to tertiary education
- engineering careers have few champions
- the gendered nature of engineering reduces the number of potential students considerably
- students interested in studying engineering had a clear preference for studying at university
- the engineering technologist role is poorly understood
- ITPs are strongly associated with the New Zealand Diploma in Engineering pathway into engineering, and the Bachelor of Engineering Technology does not fit well with this association
- tertiary education providers are rewarded for thinking of their institution's needs ahead of the industry's needs.

The Engineering Education to Employment Programme (Engineering e2e 2014) seeks to alleviate this future shortage. It represents a partnership between the Tertiary Education Commission, the ITPs, Business NZ, IPENZ and a number of organisations that employ engineers or benefit from their services.

The programme is guided by a steering group representing key stakeholder groups from the engineering sector including education and employment in a wide range of disciplines. Members are a crucial link to the wider sector and play an important role in gathering and disseminating information.

The group aims to listen, link, leverage and lead, and more specifically to:

- develop and implement a collaborative marketing campaign
- give effect to programme goals and work streams, particularly through engagement with their individual sectors
- form effective industry/education provider partnerships.

## 7.5 Motor trade

### 7.5.1 Continuous learning

The motor industry training organisation, MITO New Zealand Incorporated (MITO) recognises that, in the context of future technology changes, the existing workforce will require ongoing upskilling opportunities to keep their skills current and relevant to industry workers.

### 7.5.2 E-Learning

E-Learning has been introduced for learning programmes to meet the growing demand for an accessible approach to training in the industry that underpins the motor industry’s capability to upskill. E-Learning will allow apprentices to complete theory elements of their programme in their own time and at their own pace. They will be able to access E-Learning at any time and from any device – mobile phone, tablet or computer – which will deliver visual, practical and interactive training resources in a more flexible and convenient manner. Together with E-Learning, the programmes will continue to include a combination of workplace learning and off-job training, supporting a range of learning styles.

### 7.5.3 Vocational pathways

There is a strong perception within the motor trade recruitment industry that the chronic shortage of skilled automotive technicians was strongly influenced by the shift in primary focus of some polytechnic institutes, away from training that meets the needs of apprenticeships to training for other courses. In particular, these other courses attract fee paying foreign students. This resulted in diminished marketing activity of the polytechnic institutes towards apprenticeship courses which are the only courses that can lead to the supply of qualified automotive technicians.

MITO (2017) in collaboration with industry (see box set 5) has developed a new suite of qualifications for the automotive industry, registered on the NZQF. One example is the National Certificate in Sales (level 3) for staff who are new to, or already in, vehicle sales. The qualifications provide clearly defined career pathways. These are crucial to encouraging participation and retention in the industry. With a diminishing pool of young people entering the New Zealand workforce in general, it will be important to have a focus on vocational pathways and school-to-work transitions.

The content of learning for the qualifications can easily change to meet new knowledge and technology developments, as for electric vehicles and embedded technology in automotive panels. This content can change very quickly and MITO updates its courses in dialogue with industry.

**Box set 5 Industry collaboration on training solutions from Motor Trade Association Annual Report (2016)**

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|---|
| We are working very closely with members, training organisations, schools and relevant government agencies on short-term and long-term solutions to the skills shortage. Our advocacy team is focusing first on lobbying government and agencies to bring automotive technicians back onto Immigration's immediate skill shortage list. |

| |
|---|
| From April, people selling vehicles can study for a nationally recognised qualification.<br>MTA worked with MITO to introduce the National Certificate in Sales (Level 3) for staff who are new to, or already in, vehicle sales.<br>The training programme covers the sales process, how to target customers, build relationships and meet customer needs. There's also a strong focus on consumer and credit laws.<br>MTA Dealer Committee Chair Mike Farmer (also Managing Director, Farmer Motor Group) was one of those who pushed for the introduction of a formal qualification.<br>'MVDI used to have a certification process for someone to become a registered salesperson but that was disbanded when the MVDI Act was repealed in 2003. The new programme provides formal, national and standardised training which will be recognised by the industry and complement other training provided to sales staff.' |

### 7.5.4 Shortage of trainers

There are many challenges to industry from rapid technology change. There is already a significant shortage of experienced trained automotive technicians. As noted previously, one estimate puts the shortage at about 2,000 nationally. Apprentices need on the job training to develop tacit skills. In a context of rapid technology change, the training needed will also change rapidly. In the context of ITS implementation, experienced automotive technicians will themselves need to upskill before they can provide training to others. It is recognised that there is a significant shortage of apprentices. Small firms, in particular, reportedly need incentives to take on apprentices. Existing technicians specialise in their own brands of vehicles. It is likely that different vehicle manufacturers offshore will develop proprietary technologies. The on the job training received by an apprentice is focused on the specific makes of cars that a firm deals in and will therefore be focused on a specific type of ITS vehicle technology. Consequently training needs and training provision may not be transferrable from one business to another. This complexity will be a significant challenge for the motor industry and perhaps the training providers to manage.

### 7.5.5 Upskilling

Upskilling existing technicians will be a burden for firms and may be unaffordable, especially for small firms. Upskilling may not be feasible for many staff, particularly if the skills required are not conventional automotive skills, but are, for example, computer-related diagnostic skills. Already the level of technological change exceeds the capacity of experienced automotive mechanics to deal with it. This can become a critical issue for vehicle safety, where vehicle inspectors not familiar with new technologies, lack the capacity to detect safety risks.

Potentially, given the importance of safe vehicles for the economy, there is a very clear role for the government to support re-training of existing automotive technicians.

One view is that automotive mechanics may outsource much of the high technology work to other specialist firms. There is still a need to train such specialists, however.

Industry training providers and industry training organisations are widely believed to be well placed to provide opportunities for codified and tacit learning that is essential as the ITS technologies are implemented. There are many views on how they can provide such training.

### 7.5.6 Across sector collaboration required to provide clear career pathways for apprenticeships

It is clear that given the challenges and complexities of training, polytechnics and industry need to:

- focus on apprentice training in codified learning and place less emphasis on non-apprentice training in automotive courses
- clarify the training pathway emphasising both the industry role and the polytechnic role
- increase the number of apprenticeships (currently there is believed to be a shortage of automotive technicians of about 1,500 to 2,000)
- articulate incentives for manufacturers to support polytechnics with information on proprietary technologies for training
- define effective delivery of training to apprentices.

## 7.6 ICT professionals

### 7.6.1 Human-centric skills

ITS implementation and development will require a new type of ICT skills. There will be an increased emphasis on developing solutions that enable information to be represented to humans and to be visualised by them.

### 7.6.2 Data science

As evidence of this change in emphasis, students are now demanding a new kind of computer science training. Some universities are providing ‘data science’ courses. These are in the planning phases at present. It is envisaged that for the University of Auckland, such courses will be provided at both the undergraduate and post-graduate level. These data science courses are a merger of conventional ‘computer science’ and ‘statistics’.

### 7.6.3 Modular courses

In addition to providing micro-credentials (above), there is a view that future training needs require cross-disciplinary content. One way to achieve this is by creating modular courses within existing degree programmes. These modules provide proficiency in a discipline and are designed to train students with little prior knowledge of the discipline. This modular approach to learning enables students to add a strength in a selected course alongside their degree-oriented disciplines. Unlike micro-credentials, they are not designed to lead to qualifications by themselves. This approach has been supported by arts faculties and its merit in science and technology faculties is yet untested.

In an ITS environment, engineering students, for example, can upskill themselves with data science skills without changing the essential nature of their degree qualification. They need not become experts, but can achieve a skill level that will enable them to interact and collaborate in multidisciplinary teams.

The modular approach enables students to quickly upskill in a fast changing technology environment. Because they are not bound by the same constraints as qualification-oriented courses, they can be easily updated and adapted to changing needs. The modular courses are different from certificate of proficiency courses, which are contained in qualification-oriented courses and do require pre-requisite courses to be completed.

While modular training presents an opportunity for substantial and fast industry upskilling, there is as yet, no indication by industry of its preference for this approach.

### 7.6.4 Skills shortages

There is a current shortage of skilled ICT professionals that has developed over more than a decade. The current undersupply is being addressed by inward migration and government intervention in the form of migrant attraction programmes (Coulson 2014; Immigration New Zealand 2017) that are essential to mitigating the problem. Future supply of ITS-relevant ICT skilled workers will be compromised until this pervasive undersupply is stemmed.

In large part this problem has arisen due to the significant softening (Coulson 2014) in the numbers of students studying ICT. This is seen by the Ministry of Education as a response to the changes in the labour market in the mid-2000s, when there was an oversupply of some types of ICT skills. Since then demand has strengthened, particularly for more specialist skills and this has been reflected in the increase in numbers of ICT students.

The ongoing undersupply of students is seen by ICT professionals as a systemic problem (Coulson 2014), creating a huge shortfall in supply, arising from lack of a clear career pathway from school to ICT professions as a career.

Over the past 10 years, software engineers and ICT system test engineers number among those skills in greater demand than other ordinary skills. An Australian expert (Coulson 2014) attributes this difference to the availability of outsourcing to meet demand for ordinary skilled ICT workers. The more specialised skills are harder to outsource. Further, Australian reports suggest employers are seeking ICT professionals with a diverse range of skill and experience needs that are not readily available. In particular, it is reportedly difficult to find ICT professionals with the right mix of technical and soft skills (such as communication and stakeholder engagement).

This difficulty is reportedly evidenced (Coulson 2014) in an increased demand for positions with emerging technologies (such as mobile-based applications). There are indications that this difficulty in securing the right ICT professionals will extend to future skills that are relevant to ITS implementation, such as for workers with experience in web development, mobile applications and cloud computing experience.

Consequently, the prevailing undersupply of skilled ICT professionals presents a significant downside risk to future supply of ICT professionals in ITS-related occupations.

## 7.7 Employer – education engagement

Business is showing leadership in addressing training needs and one example (see box set 6) is provided by Fusion Networks (2017). It is getting directly involved in education by developing an intern programme. This provides a career pathway to create future employees starting from assisting developing secondary school students interested in technology.

This engagement between a private sector firm and the education sector has co-created learning programmes with two polytechnic institutes and a private teaching organisation. By combining practical skills training with a traditional education framework, it seeks to match practical learning with theory.

**Box set 6 Fusion Networks announces its internship pilot (Source: Fusion Networks 2017)**

The Fusion IT Intern Pathway is a new innovative programme from Fusion, co-creating digital learning to prepare young people for the 21st century workforce.

It’s is a three-way partnership between Tamaki College, the first full digital learning secondary school in NZ, the Manaiakalani Education Trust, the award winning programme that’s transforming student’s education in low decile schools, and Fusion Networks.

Kiwi IT company Fusion is used to solving complex IT issues with agile thinking. When Tamaki College challenged Fusion to find a way to help students build a career in technology, Fusion looked to change traditional academic learning with hands-on and practical focused workplace experience. The mix was a key factor for a company like Fusion, which had discovered that graduates that hit the workforce with hands-on practical experience are confident, and high performers in the workplace.

## 7.8 Conclusions

The new environment of ITS technology calls on diverse leadership across the transport sector:

- Students are called upon to actively seek opportunities to broaden their training to acquire skills that enable them to collaborate with other skilled workers from different disciplines.
- Training organisations need to be flexible to accommodate new skills demanded, but must adhere to clear pathways for careers, that are co-defined with industry.
- Business has a clear role to define skills required currently and to engage in activities to assess future skills required.
- Original equipment manufacturers have a role to provide knowledge bases about their technologies to training organisations and to businesses to enable effective training.
- The government has a role to provide incentives and to reduce barriers in all these interactions.
- The government has a role to build public awareness at all levels, from school age to adult on the future of ITS and its implications.

ITS will transform transport operations and management away from a focus on infrastructure to a focus on management of a system of human actors and vehicles and infrastructure. Training for transport professionals and technicians will need to encompass a wider field of codified knowledge as well as provide skills to carry out tasks in rapidly changing systems. Training for them will also need to focus on skills to enable collaboration with skilled workers in wider fields. There will need to be an emphasis on continuous learning to address changing skills needs.

Industry stakeholders are aware that motor trade technicians training must address the current chronic shortage of skilled technicians before attempting to target long-term skills needs. Primarily this is because future skilled workers are necessary to train future apprentices on the job. While cross-sector collaborations between industry and training organisations are currently in development, there is a need to deepen these to provide a greater emphasis on delivering apprenticeship training and to provide clear training pathways. Introduction of new technologies under ITS will necessitate action by manufacturers to provide knowledge bases on them to trainers, both in training institutions and in the workplace.

For ICT professionals and technicians, future training will need to emphasise delivery of human-centric solutions. Big data is important to ITS and the recent introduction of data science courses at tertiary institutions that link conventional computer science and statistics is an important step to provide skills to operate in big data environments. Flexible training to accommodate diverse human-centric perspectives can be achieved without formal credentials, hence the essential ICT skills are enhanced quickly and easily to enable collaboration with other fields.

Industry leadership in assessing and delivering training needs is essential. ITS firms precisely understand the current skills needs. By establishing codified learning courses in collaboration with training providers, industry can set the short-term learning agenda, from which the long-term agenda can evolve. By creating workplace learning opportunities, firms can build the absorptive capacity of their new and future workforce, so that they can continually upskill as ITS implementation evolves.

# 8 Projections of workers in demand in relevant ITS occupations from 2020 to 2035

## 8.1 Introduction

This chapter presents projections of numbers in occupations in demand to 2035, under:

- a non-ITS environment – the baseline
- a slow uptake ITS implementation – scenario one
- a rapid uptake ITS implementation – scenario four.

The projection for an occupation in a given scenario is indicative only to enable comparison with:

- historic trends
- projected baseline for that occupation
- projections of other scenarios.

These are not to be interpreted as forecasts.

The historic growth rates from 1991 to 2015 for the main aggregate groups of the 55 occupations are also provided as a reference line.

The baseline projection for each scenario is an employment projection derived from a computable general equilibrium (CGE) model. Each scenario takes the CGE-derived baseline as representing employment by occupation in the future states of the world in the absence of ITS implementation.

Then for each scenario for each occupation, the baseline employment projection is perturbed or shocked upwards or downwards, corresponding to our estimates of the incremental change in demand for occupational employment due to ITS implementation. This perturbation in labour demand is assumed to be a partial shock over time, which we do not assume is immediately matched by labour supply.

Hence each scenario consists of two components, which we assume for simplicity are additive:

- a baseline component representing future employment in the absence of ITS
- an incremental component representing the change in demand for occupational skills due to ITS.

The baseline employment projections are based on Statistics New Zealand's median population projections to 2068 (basis 2016) (Statistics New Zealand 2016). These assume annual net inward migration of 60,000 in 2017 decreasing by 9,000 annually to 15,000 in 2022 and beyond.

It would be very complicated to prepare a CGE model to estimate equilibrium levels of employment (where labour supply and labour demand are matched) under ITS implementation to 2035. Although CGE modelling provides economy-wide and sectoral general equilibrium projections, the analysis would still be partial in the sense that certain second and third order effects of ITS in general and of AVs in particular are not incorporated. These effects have been described and discussed by Milakis et al (2017) in terms of first-order (traffic, travel cost and travel choices), second order (vehicle ownership and sharing, location choices and land use, and transport infrastructure) and third order (energy consumption, air pollution, safety, social equity, economy and public health).

## 8.2 Historical movements

We estimated occupation growth rates for the 20 years between 2015 and 2035 using Statistics New Zealand Census data for 1991 and 2015 employment data. Given there has been a change in occupation classifications since the 1991 Census, analysis at the individual occupation level would require numerous assumptions to be made about the data, and therefore our analysis is provided only for the group level. Matching between the classifications at the group level is more robust than at the lower level.

Table 8.1 shows the employment totals at 1991, 2015 and the project employment total for 2035; in addition it shows the per annum growth rate that has occurred between 1991 and 2015 and the projected per annum growth estimated between 2015 and 2035.

**Table 8.1 Occupation groupings, employment movements and projections, baseline, 1991–2035**

| **Occupation** | | | | **1991–2015** | **2015–2035** |
|---|---|---|---|---|---|
| | **1991** | **2015** | **2035** | **%pa** | **%pa** |
| Engineer occupation group total | 20,223 | 27,880 | 39,685 | 1.3% | 1.8% |
| ICT occupation group total | 20,244 | 52,025 | 72,405 | 4.0% | 1.7% |
| Driver occupation group total | 30,528 | 47,295 | 68,105 | 1.8% | **1.8%** |
| Repair and maintenance occupation group total | 18,441 | 22,785 | 32,420 | 0.9% | 1.8% |
| Logistics occupation group total | 5,634 | 6,615 | 8,360 | 0.7% | 1.2% |
| Salesperson occupation group total | 2,493 | 3,455 | 4,465 | 1.4% | 1.3% |
| **Total 55 key occupations** | **95,070** | **160,055** | **225,440** | **2.1%** | **1.7%** |

## 8.3 Model overview

The workforce model was developed to project employment in key occupations and occupation groups (as discussed in chapter 6), from a 2015 base year, forward to 2035 in five-year periods. Employment numbers for the 2015 base year in the model were developed using data from the 2013 Census to apportion, at a detailed occupation classification level, published employment numbers from the Ministry of Business, Innovation and Employment (MBIE) medium-term employment forecasts for 2015 (MBIE 2017) at a higher level of aggregation. We used MBIE numbers so we could provide a publicly available basis for the projections. 2013 Census data was sourced by age group, length of time in New Zealand and total employment, for each occupation.

### 8.3.1 2015 base year

The 2015 base year for the model was developed by taking 2013 Census data for each occupation and determining the occupation share of employment within the occupation group. This share of employment within the occupation group was then used to distribute the occupation group employment numbers from the 2015 MBIE data across each of the occupation groups.

For example 4,368 people according to the 2013 Census were employed as civil engineers. This was 7.4% of the design, engineering, science and transport professionals occupation group which had 59,151 people employed in it. This 7.4% was multiplied by the 76,770 employed in the design, engineering, science and transport professionals occupation group according to MBIE. Therefore an estimated 5,669 people were employed as civil engineers in 2015.

### 8.3.2 Baseline employment growth rates

The baseline level of employment growth represents expected growth in the 55 occupations in a non-ITS environment within the 20-year period from 2015 covered by the model.

The base employment growth rates for the workforce model were taken from the Business and Economic Research Limited (BERL) computable general equilibrium (CGE) model. This model projects gross output, employment and GDP growth rates out to 2050, in 10-year periods. In addition to projecting these growth rates the CGE model also projects a number of other variables, including price, capital and income changes. The BERL CGE model uses Treasury and other New Zealand Government data, along with BERL data to estimate the projected growth rates out to 2050. The BERL CGE model is described in appendix A.

The employment growth projections from the BERL CGE model are for aggregates of detailed occupation groups defined at a more detailed classification level. This means it needs to be assumed that each detailed occupation will respond identically to the aggregate growth rate.

Under the BERL CGE model, the ICT professionals occupation group was expected to grow by 0.83% out to 2020, then by 1.67% out to 2030, and then by 2.51% out to 2035. Therefore it is assumed that the base growth rate for each ICT occupation within this group will match these growth rates, prior to any adjustments under the scenarios.

**Table 8.2 Occupation groupings, employment projections, baseline, 2015–2035**

| Occupation | Total employment counts | | | | | 2015–2035 |
|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | %pa |
| Engineer occupation group total | 27,880 | 29,205 | 31,910 | 34,865 | 39,685 | 1.8% |
| ICT occupation group total | 52,025 | 54,220 | 58,900 | 63,975 | 72,405 | 1.7% |
| Driver occupation group total | 47,295 | 49,520 | 54,255 | 59,465 | 68,105 | 1.8% |
| Repair and maintenance occupation group total | 22,785 | 23,890 | 26,115 | 28,550 | 32,420 | 1.8% |
| Logistics occupation group total | 6,615 | 6,790 | 7,205 | 7,635 | 8,360 | 1.2% |
| Salesperson occupation group total | 3,455 | 3,565 | 3,800 | 4,055 | 4,465 | 1.3% |
| **Total 55 key occupations** | **160,055** | **167,190** | **182,185** | **198,545** | **225,440** | **1.7%** |

### 8.3.3 Replacement rates

Within the workforce model, replacement rates are calculated for each occupation to provide an indication of the supply needed by this occupation. If the occupation is growing between 2015 and 2035, along with the new workers needed, the occupations will need to replace the existing workers leaving the occupation.

Replacement rates are the percentage of occupation that needs to be replaced for the occupation to maintain its employment level. Every occupation has people retiring, moving to a different occupation, leaving the workforce, or leaving New Zealand. These people need to be replaced otherwise the employment within the occupation will drop. The replacement rate is the estimated rate for each occupation at which replacement employees are needed.

For the workforce model, the replacement rate was estimated for each occupation, using an age breakdown of each occupation at the 2006 and 2013 Census, by age groups of five years. The theory behind the replacement rate calculation is that older age groups within an occupation will decline in numbers, as people leave the occupation, while numbers in younger age groups will increase as new workers enter the occupation. A decline in the number of people employed in the occupation means new replacements will be needed to make up for the decline arising from this age group.

For each occupation the workforce model will take the age breakdown from 2015 and age the workforce for the occupation across the 20 years, using the replacement rates calculations to estimate the age of new and replacement workers entering the occupation and the number of people leaving the occupation based on the prevailing replacements rates for each age group within the occupation.

**Table 8.3 Replacement rates, by occupation groupings**

| Occupation | Replacement rates |
|---|---|
| Engineer occupation group total | 6.6% |
| ICT occupation group total | 2.3% |
| Driver occupation group total | 13.1% |
| Repair and maintenance occupation group total | 10.1% |
| Logistics occupation group total | 15.5% |
| Salesperson occupation group total | 28.4% |
| **Total 55 key occupations** | **8.5%** |

A new motor mechanic is employed in 2015 at the age of 25. Between 2015 and 2020 he ages five years to 30 years. Across this period 2% of the 25–29 year old workforce is replaced. Between 2020 and 2025, he ages from 30 to 35 years. Across this period 18% of the 30–34 year old workforce is replaced. Between 2025 and 2030, he ages five years to 40 years. Across this period 17% of the 35–39 year old workforce is replaced. Finally between 2030 and 2035, he ages five years to 45 years. Across this period 11% of the 40-44 year old workforce is replaced.

### 8.3.4 Recent migrants

One of the main sources of new entrants to an occupation, alongside new graduates and people changing occupation, is new or recent migrants. For this project and model, new or recent migrants are defined as people who have entered New Zealand within the last five years. This definition has been used because it fits with the models five-year time period calculations.

Counts of recent migrants within each occupation were obtained from the 2006 and 2013 Census. These counts allow us to determine in both 2006 and 2013 the percentage of people in the occupation who were recent migrants.

For example in 2013 there were 80 people working as urban and regional planners, who had entered New Zealand within the previous five years. Dividing 80 by 1,810 (the total number of people working as urban and regional planners in the 2013 Census), tells us that around 4% of the urban and regional planner occupation in 2013 were recent migrants.

An average on the 2006 and 2013 results for each occupation was then calculated for use in the model. Geotechnical engineers have the highest percentage of recent migrants in their workforce with 22%, while tanker drivers have the lowest with 1% of their workforce being recent migrants.

Within the model the recent migrant percentage of workforce can be used in each five-year calculation (2020, 2025, 2030 and 2035) to estimate the number of recent migrants that may have come to New Zealand and entered into the occupation over the previous five years. It also provides a rough estimate of the proportion of new and replacement workers that are recent migrants, compared with new graduates or people entering the occupation from another occupation. As part of this calculation it needs to be assumed that the number of recent migrants in this occupation at the 2006 and 2013 Census years is typical of the occupation and not affected by one-off factors that may have seen a higher or lower number of recent migrants into these occupations in these two Census years.

For example with the urban and regional planner's occupation, 4% of the workforce was in 2013 made up of recent migrants. By 2015 this is an estimated 124 people out of a workforce of 2,356 people. Using the 4% and the base projections for urban and regional planners, by 2035 it is expected that 177 people will be recent migrants (people who have come to New Zealand after 2030). At the same time it is expected under the base projection that between 2030 and 2035, 500 new and replacement workers will be needed in this occupation.

### 8.3.5 Model summary

In summary the workforce model projects the employment numbers for workers within each of 55 occupations linked to the implementation of ITS systems in New Zealand, under various scenarios of ITS adoption, across five-year time periods from 2015 out to 2035. In addition to projecting the employment numbers, the model estimates the number of new and replacement workers needed every five years, and estimates the number of recent migrants that have entered each occupation's workforce within the last five years.

Therefore the workforce model is able to project for each scenario an estimate of the employment numbers for each of the 55 occupations, taking into account retirement of workers, estimates of the number of workers potentially entering the workforce from overseas, to meet the demand, and estimates of the potential supply needed to be found within New Zealand, as well as from net mobility between other occupations..

## 8.4 Incremental growth rates for scenarios

For this report, ITS development scenarios one and four were run through the workforce model. These scenarios are discussed in chapter 5. Scenario one is characterised by a slow progression path, with low technology introduction, and low private, business and governmental development and implementation of ITS in New Zealand. Scenario four is characterised by a rapid progression path, with high technology introduction, and medium private, business and governmental development and implementation of ITS in New Zealand.

For each scenario, different assumptions are made about the impact on demand for the occupation groups spanning the 55 occupations. These assumptions are specified in terms of incremental annual growth rates in employment for each of the 55 occupations as shown in appendices C and D. The incremental annual growth rates applied to the CGE model produce the employment counts in the five-year periods shown in these appendices.

The incremental growth rates were selected to correspond to a level of take up of AVs by 2035 consistent with the scenarios. Hence the level of take up of AVs is a measure of the level of implementation of ITS. The selection of growth rates and the different impact on different occupations was made based on expectations of stakeholders and experts together with global expectations as presented above in this report.

## 8.5 Model results

### 8.5.1 Scenario one

Scenario one is characterised by a slow progression path, with low technology introduction, and low private, business and governmental development and implementation of ITS in New Zealand.

This is shown in chapter 5, where the scenario has the following defined growth in several different variables listed below:

- vehicles – low introduction
- data analytics – medium achievement
- national infrastructure – low/minimum achievement
- local infrastructure – low/minimum achievement
- businesses – low/minimum achievement
- households – low/minimum achievement
- government public policy – low/minimum achievement

With the workforce model the results of this scenario can be projected from 2015 to 2035. Within the model each occupation is projected to 2035, with the 55 occupations combined into six occupation groupings for reporting purposes. These results for the occupation groupings are shown in table 8.4.

**Table 8.4 Occupation groupings, employment projections, growth from baseline, scenario one, 2015–2035**

| Occupation | Total employment counts | | | |
|---|---|---|---|---|
| | 2020 | 2025 | 2030 | 2035 |
| Engineer occupation group total | 0.7% | 2.0% | 3.4% | 4.9% |
| ICT occupation group total | 0.8% | 2.2% | 3.4% | 4.9% |
| Driver occupation group total | -0.6% | -1.9% | -3.2% | -5.0% |
| Repair and maintenance occupation group total | -0.1% | -0.3% | -0.5% | -0.8% |
| Logistics occupation group total | 0.6% | 1.7% | 3.0% | 4.8% |
| Salesperson occupation group total | 0.0% | 0.0% | 0.0% | 0.0% |
| **Total 55 key occupations** | **0.2%** | **0.5%** | **0.8%** | **1.0%** |

In 2015 the 55 key occupations employ 160,055 people, with the largest numbers employed in the ICT occupation grouping with just over 52,000, and the driver occupation grouping employing almost 47,300 people.

For scenario one, we assumed different growth in occupations demanded, as shown in appendix C. Our growth rate assumptions were guided by expectations of experts and stakeholders at workshops and by the order of magnitude of growth rates for similar occupations provided in the TSC (2016) report.

Under this scenario the total numbers employed in these occupations will grow by 1.8% per annum across the 20 years to 227,700 workers. Within this total growth the fastest growth will be in the engineer occupation group which is projected to grow by 2% per annum, while the largest growth in actual numbers is in the ICT occupation group which is projected to add a further 24,000 people to its workforce across the 20 years.

On the other side the salesperson occupation group will see the slowest growth at 1.3% per annum and the lowest growth in actual numbers at 1,000 new employees from 3,455 people in 2015.

In total only the ICT and engineer occupation groups under this scenario will grow at faster than the 1.8% per annum average seen for all occupations as a group.

Overall the national workforce is expected to grow by 1.1% per annum between 2015 and 2035. This shows that even under the low scenario it is expected that over the next 20 years there will be strong demand for more workers to enter into these occupations. Future matching of labour supply with demand will be influenced by the extent to which the current chronic supply shortages of skilled labour can be alleviated.

### 8.5.2 Scenario four

Scenario four is characterised by a rapid progression path, with high technology introduction, and medium private, business and governmental development and implementation of ITS in New Zealand. This is shown in chapter 5, where the scenario has the following defined growth in several different variables listed below:

- vehicles – high introduction
- data analytics – high achievement
- national infrastructure – medium achievement
- local infrastructure – medium achievement
- businesses – medium achievement
- households – medium achievement
- government public policy – medium achievement.

With the workforce model the results of this scenario can be projected from 2015 to 2035. Within the model each occupation is projected to 2035, with the 55 occupations combined into six occupation groupings for reporting purposes. These results for the occupation groupings are shown in table 8.5.

In 2015 the 55 key occupations employ 160,055 people. Under this scenario the total numbers employed in these occupations will grow by 1.9% per annum across the 20 years to 232,500 workers.

As for scenario one above, our growth rate assumptions were guided by expectations of experts and stakeholders at workshops and by the order of magnitude of growth rates for similar occupations provided in the TSC (2016) report.

**Table 8.5 Occupation groupings, employment projections, growth from baseline, scenario four, 2015–2035**

| Occupation | Total employment counts | | | |
|---|---|---|---|---|
| | 2020 | 2025 | 2030 | 2035 |
| Engineer occupation group total | 1.9% | 5.5% | 9.3% | 14.9% |
| ICT occupation group total | 1.9% | 5.8% | 9.3% | 14.9% |
| Driver occupation group total | -2.0% | -5.9% | -9.7% | -15.0% |
| Repair and maintenance occupation group total | -0.3% | -0.9% | -1.4% | -2.2% |
| Logistics occupation group total | 1.7% | 5.2% | 9.0% | 14.9% |
| Salesperson occupation group total | 0.0% | 0.0% | 0.0% | 0.0% |
| **Total 55 key occupations** | **0.4%** | **1.2%** | **1.9%** | **3.1%** |

Within this total growth the fastest growth will be in the engineer occupation group which is projected to grow by 2.5% per annum, while the largest growth in actual numbers is in the ICT occupation group which is projected to add a further 31,200 people to its workforce across the 20 years.

By comparison, the salesperson occupation group will see the slowest growth at 1.3% per annum and the lowest growth in actual numbers at 1,000 new employees from 3,455 people in 2015.

Under scenario four there is a much stronger growth seen in the engineer and ICT occupation groups, while the driver, repair and maintenance, and logistics occupation groups still increase, but at a slower rate than seen in scenario one or in the base projections. As shown in the table there is a much stronger growth in the engineer and ICT occupation groups, with almost 50,000 new workers needed in these occupations across the next 20 years. These new workers will be needed to build, maintain and analyse the infrastructure needed to develop ITS within New Zealand at a rapid rate.

### 8.5.3 Comparison between scenarios

Comparing the projection results between the two scenarios requires a more in-depth analysis for individual occupations. We select two occupations to illustrate this comparison: taxi drivers and IT systems analysts. We expect projections for taxi drivers to show lower growth than the baseline projection for each scenario. We expect projections for IT systems analysts to show higher growth than the baseline for each scenario.

Figure 8.1 shows the count of employment for the taxi driver occupation across the 20-year period for both scenarios.

Figure 8.2 shows that the growth in the taxi driver occupation between 1991 and 2015, a period of 24 years, was 1.1% per annum. This is compared with the 1.8% per annum growth projected for the 20 years between 2015 and 2035.

Figure 8.3 provides the total count of new and replacement workers needed every five years for the taxi driver occupation across the same period.

**Figure 8.1 Total count of taxi driver employment, scenario one and four, 2015–2035**

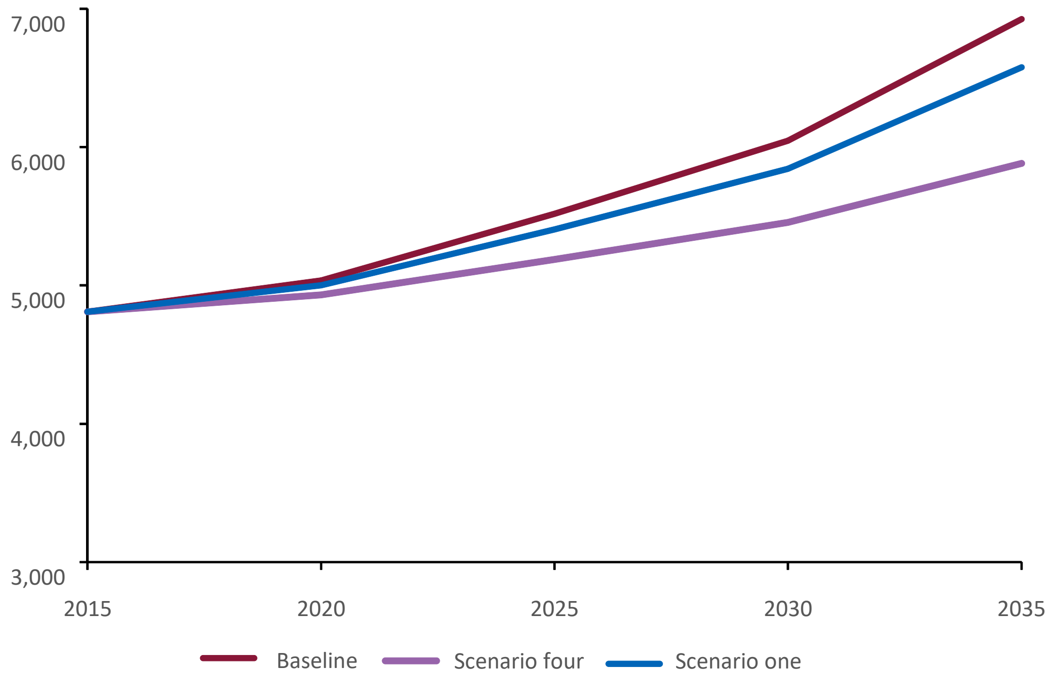


Figure 8.1 shows that under scenario one the number of taxi drivers projected would rise from 4,800 in 2015 to 6,600 in 2035, at a rate of 1.6% per annum, while under scenario four the number of taxi drivers would only rise to 5,900 by 2035, an increase of 1.0% per annum. This shows that the difference between scenarios one and four for the taxi driver occupation is that under scenario four around 700 less workers will be needed by 2035, compared with scenario one.

**Figure 8.2 Total count of taxi driver employment, scenario one and four, 1991–2035**

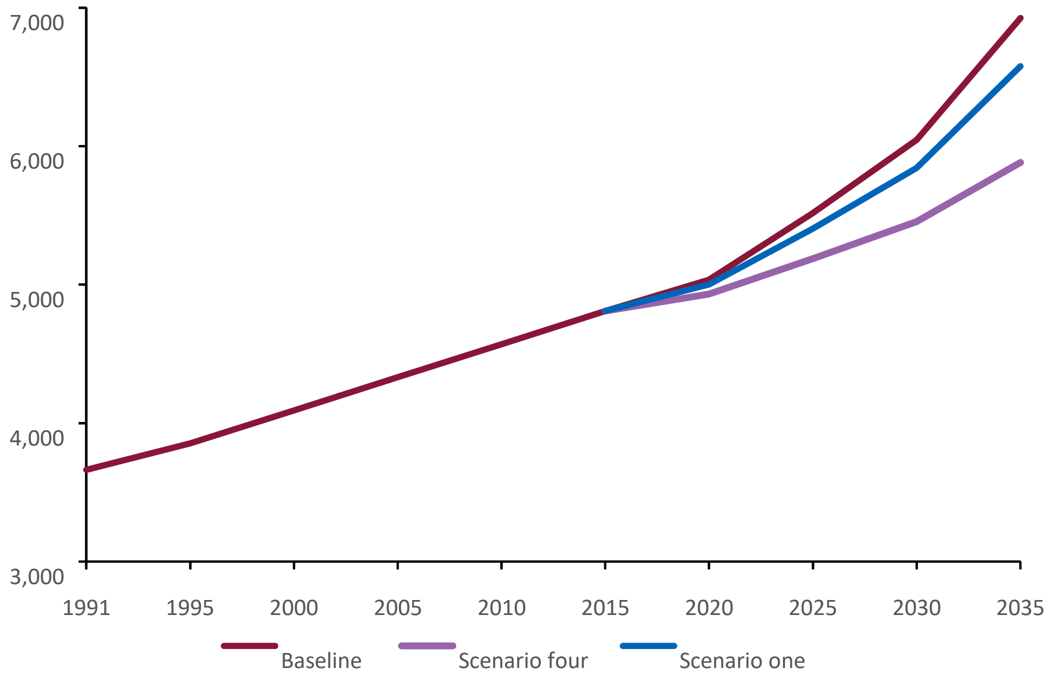
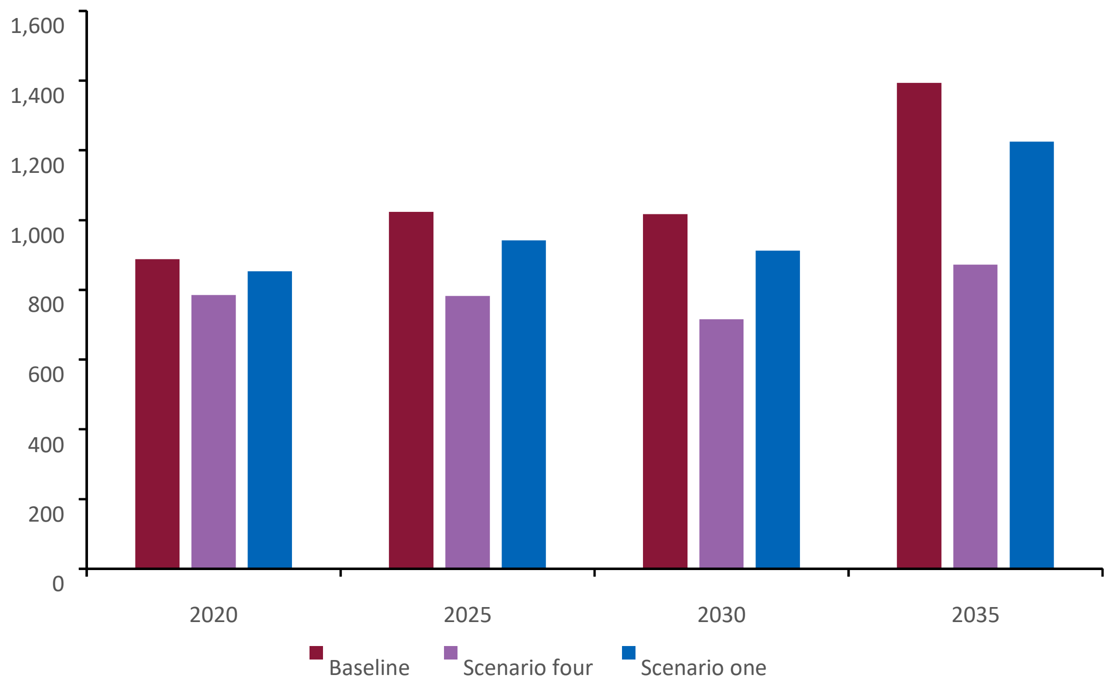



**Figure 8.3 Total count of new and replacement workers needed for taxi driver occupation**



Under scenario one it is projected that between 2015 and 2020 around 850 new and replacement workers would be needed for the taxi driver occupation. This supports a rise of around 200 in the total number employed in this occupation by 2020. In the period to 2025 and to 2030 around 900 to 950 new and replacement workers are projected for each of the five-year periods. Lastly just over 1,200 new and replacement workers are projected for the five years between 2030 and 2035.

For scenario four, while there is a similar number of new and replacement workers projected for the first five year period, the gap between the number of new and replacement workers in scenario one and four widens from just 70 in the five years to 2020, out to 350 in the five years between 2030 and 2035.

Figure 8.4 provides the total count of employment for the IT systems analyst occupation across the 20-year period for both scenarios. The figure shows that under scenario one the number of projected IT systems analysts would rise from 12,200 in 2015 to 17,900 in 2035, at a rate of 1.9% per annum, while under scenario four the number of IT systems analysts would rise to 19,600 by 2035, an increase of 2.4% per annum. This shows that the difference between the scenarios one and four for the IT systems analyst occupation is that under scenario four around 1,700 more workers will be needed by 2035, compared with scenario one.

Figure 8.5 provides a longer-term view of the growth in employment in this occupation. This figure shows that the growth in the IT systems analyst occupation between 1991 and 2015, a period of 24 years, was 3.5% per annum. This is compared with the 1.7% per annum growth projected for the 20 years between 2015 and 2035.

**Figure 8.4 Total count of IT systems analyst employment, scenarios one and four, 2015–2035**

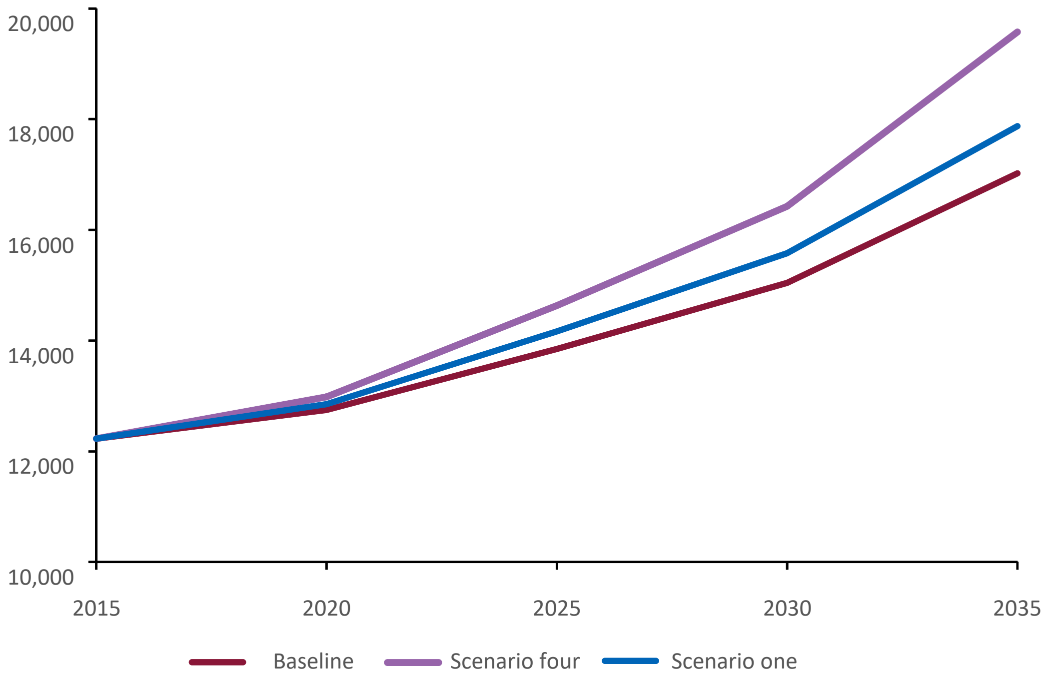


**Figure 8.5 Total count of IT systems analyst employment, scenario one and four, 1991–2035**

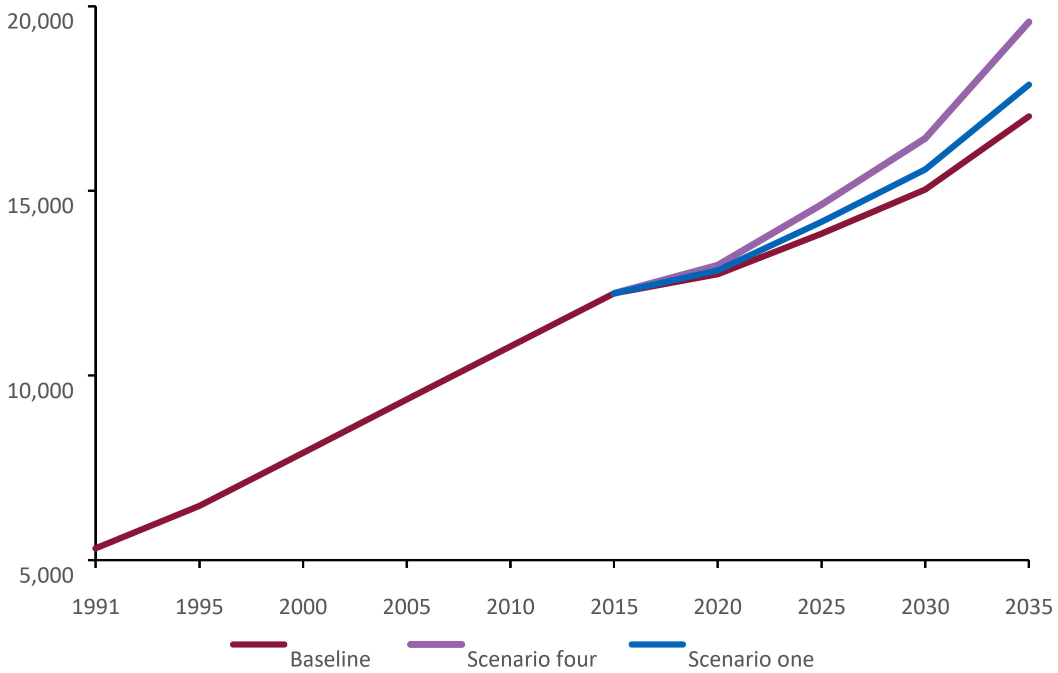
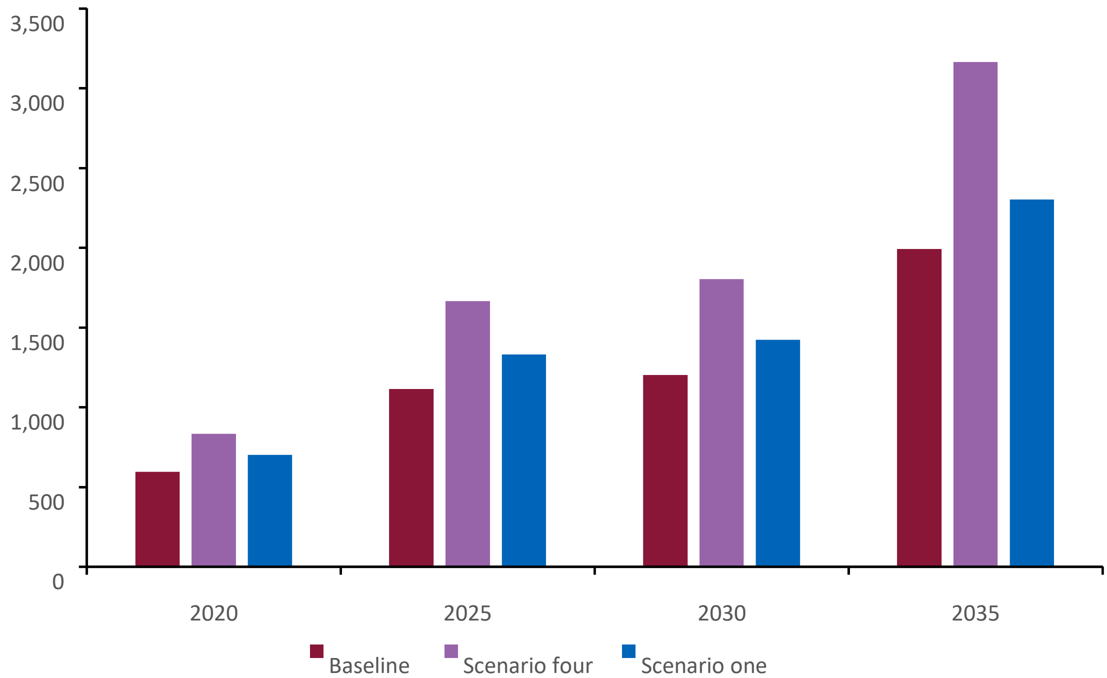



Figure 8.6 provides the total count of new and replacement workers needed every five years for the IT systems analyst occupation across the same period.

**Figure 8.6 Total count of new and replacement workers needed for IT systems analyst occupation**




Under scenario one it is projected that between 2015 and 2020 around 700 new and replacement workers would be needed for the IT systems analyst occupation. This supports a rise of around 600 in the total number employed in this occupation by 2020. In the period to 2025 and to 2030 around 1,300 to 1,400 new and replacement workers are projected for each of the five year periods. Lastly just over 2,300 new and replacement workers are projected for the five years between 2030 and 2035.

For scenario four, there is a higher number of new and replacement workers projected for each of the five-year periods, with 830 in the five years to 2020, almost 1,700 to 2025, 1,800 to 2030, and finally almost 3,200 new and replacement workers projected in the five years to 2035. Overall the gap between the number of new and replacement workers in scenarios one and four widens from 130 in the five years to 2020, out to 860 in the five years between 2030 and 2035.

## 8.6 Conclusions

Overall the difference in total employment across the 55 occupations between the two scenarios will be around 5,000 more employed under scenario four than scenario one, by 2035. Beneath that headline figure it can be seen that under scenario four the engineer and ICT occupations groups will expand at a faster rate than under scenario one, while at the same time the other occupation groups will see slower growth rates under scenario four compared with scenario one.

Table 8.6 shows the total employment counts at 2035 under the baseline, scenario one and scenario four projections. Also shown in the table are the percentage differences between the scenarios and the baseline projections, as well as showing the differences between the scenarios.

**Table 8.6 Occupation groupings, employment projections, growth from baseline, scenarios one and four, 2015–2035**

| Occupation | Total employment counts 2035 | | | Difference between scenario and baseline | | | |
|---|---|---|---|---|---|---|---|
| | Baseline | Scenario one | Scenario four | Scenario one | Percentage change | Scenario four | Percentage change |
| Engineer occupation group total | 39,685 | 41,640 | 45,615 | 1,955 | 4.9% | 5,930 | 14.9% |
| ICT occupation group total | 72,405 | 75,965 | 83,215 | 3,560 | 4.9% | 10,810 | 14.9% |
| Driver occupation group total | 68,105 | 64,670 | 57,875 | -3,435 | -5.0% | -10,230 | -15.0% |
| Repair and maintenance occupation group total | 32,420 | 32,175 | 31,700 | -245 | -0.8% | -720 | -2.2% |
| Logistics occupation group total | 8,360 | 8,765 | 9,605 | 405 | 4.8% | 1,245 | 14.9% |
| Salesperson occupation group total | 4,465 | 4,465 | 4,465 | 0 | 0.0% | 0 | 0.0% |
| **Total 55 key occupations** | **225,440** | **227,680** | **232,475** | **2,240** | **1.0%** | **7,035** | **3.1%** |

As the table shows by 2035, both scenarios have a higher total employment count compared to the baseline, with scenario one just over 2,200 higher and scenario four just over 7,000 higher. As seen in the table both scenarios have higher employment counts for engineers, ICT, and logistics occupation groups, while also having lower counts for drivers, along with repair and maintenance occupations. The latter numbers do not account for the current chronic shortage of automotive technicians and are largely driven down by automotive panel beaters and body builders.

This table shows, compared with the baseline projection, the expected changes in the makeup of the ITS workforce, with both scenarios needing more engineers to build and maintain the physical side of the ITS, and ICT professionals to build and maintain the software needed to run the ITS. On the flip side compared with the baseline both scenarios require less drivers and less repair and maintenance of vehicles, as ITS require fewer human drivers and result in fewer crashes requiring repairs.

# 9 Conclusions

## 9.1 Technological change

Historic technology cycles have much to tell us about the expected pattern of technology uptake for ITS. In general a characteristic growth path (an S-curve shape) is followed, initially slow and cautious, then rapid and enthusiastic and then dampened and exhausted. Subsequently, beyond our projection period, uptake may decline sharply to zero or a low level.

ITS technological uptake supported by demand for continuous improvement in connected mobility will follow an S-curve pattern of growth, similar to historic technology cycles.

We expect an S-curve pattern for ITS with unique New Zealand characteristics. In this study, to understand these unique features, we consulted local reports and local stakeholders including experts from academia, business and policy areas. We selected five S-curves for five scenarios with the following likely outcomes for long-run connected mobility:

- Slow uptake – no enthusiasm for connected mobility by firms, households and government
- Medium uptake with no incentives – government agencies are reluctant to invest or subsidise ITS implementation and take-up of technologies, while businesses cautiously invest
- Medium uptake with incentives – government agencies are willing to support and invest and businesses and households cautiously support
- Rapid uptake – firms, households and government demand connected mobility, are confident in ITS technology and the technology is available
- Mixed rapid and slow uptake – firms, households and government are initially enthusiastic about connected mobility, but barriers to uptake of technology emerge and no further uptake ensues.

## 9.2 Economics of skills demand under technological change

The economic literature tells us that changes in occupation and skills follow technological change. We visualise an occupation as a basket of skills, some or all of which will be affected by technological change. Selected economics literature also tells us that changes in the qualifications of those employed follow changes in skills demanded. We investigate and develop a qualification needs assessment based on the skills gap assessment. International literature and New Zealand perspectives guide this. We quantify the skills gap and training needs assessment to 2035 with projections of future labour demand. These are based on projected economic growth for the whole economy, adjusted for estimated changes in growth of relevant occupations due to ITS implementation.

Consequently, our methodology in this project was to create scenarios for likely envelopes of ITS technologies each with a different S-curve, to guide us in understanding skills needs and in assessing skills gaps. Our conceptual framework for this research therefore consisted of:

- understanding scenarios for the relevant ITS technological change by 2035 for New Zealand
- assessing the change in skills demanded resulting from scenarios of technological change
- quantifying the change in demand for new workers in skilled occupations to meet this future demand.

## 9.3 Global perspectives

Globally, the widely held view is that fully autonomous or near fully autonomous vehicles in controlled environments are likely to lead to ITS implementation by 2035. At the same time, various levels of semi-autonomous vehicles will be continuously improving. As a broad estimate, for a global perspective, it is likely that ITS implementation in 2035 will be characterised by vehicle fleets with up to 20% of fully autonomous vehicles, mostly in controlled environments.

Globally, skills gap assessments indicate that ITS implementation will result in increased demand for skilled professionals in many fields, including cybersecurity, IT design, data management and data analytics, and human centric fields. The studies do not cover technically skilled workers such as automotive technicians and drivers.

Reports from the UK and the US indicate that new training methods to address ITS skills development should:

- be guided by a skills gap assessment and a career pathway
- include new knowledge bases for ITS disciplines
- include on the job training, including for professional occupations
- facilitate cross-sectoral collaboration
- create recognisable accreditation for new training consistent nationally and across industries
- provide opportunities for life-long continuous education
- include training in non-traditional disciplines
- involve cross-sectoral governance and leadership
- include targeted courses in curricula.

## 9.4 ITS technology scenarios for New Zealand

By 2035, ITS implementation is likely to result in a limited take-up of ITS technology associated with:

- a high level of semi-autonomous vehicles, up to about 37% of the national vehicle fleet at SAE levels 2 to 4 of autonomy
- a low level of fully autonomous vehicles, up to about 15% of the vehicle fleet, but concentrated in controlled domains
- a proportionately greater take up by businesses and passenger fleet businesses than households
- a lower motor vehicle crash rate overall due to the enhanced safety benefits that semi and fully autonomous guidance provides
- a sizeable proportion of transport management dedicated to supporting controlled domains and to developing new ones
- a widespread take up of ICT technologies associated with both embedded and nomadic telematics.

## 9.5 Skills gap assessment for New Zealand

A deficit in the supply of skilled workers, to match new areas of demand associated with the implementation of ITS, is expected by 2035, assuming current trajectories of supply continue.

In summary, our qualitative skills gap assessment is:

- Current occupations are likely to still be in demand, but skills required of them will change significantly.
- All occupations will require skills to access and operate on-line tools and on-line resources, though with the development of the IoT, such skills may be ubiquitous by 2035.
- Commercial freight drivers and passenger transport drivers are likely to require new skills to operate near-autonomous vehicles in controlled environments.
- Automotive technicians will require new skills to maintain complex high-technology devices in vehicles. Some of these skills may be specific to particular brands and models. They will probably need to operate computer-based diagnostic equipment and interact with specialists locally and on-line.
- Professional and technical engineers will need new skills to enable their collaboration in multidisciplinary teams with others from diverse disciplines to provide user friendly and people-focused transport solutions. They will need skills for addressing transport environments as systems involving people, infrastructure and connected mobility outcomes. They will require human-centric skills to complement their STEM-based skills.
- ICT professionals and technicians, like engineers, will need collaborative and human-centric skills. Data analytic skills will be in high demand, but coupled with skills for creativity and design. In addition, skills will be in high demand to create new solutions for people, to provide connectivity of embedded telematics in vehicles with other devices, cellular networks and the cloud.

## 9.6 Training needs assessment for New Zealand

The new environment of ITS technology calls on diverse leadership across the transport sector:

- Students are called upon to actively seek opportunities to broaden their training to acquire skills that enable them to collaborate with other skilled workers from different disciplines.
- Training organisations need to be flexible to accommodate new skills demanded, but must adhere to clear pathways for careers that are co-defined with industry.
- Business has a clear role to define skills required currently and to engage in activities to assess future skills required.
- Original equipment manufacturers have a role to provide knowledge bases about their technologies to training organisations and to businesses to enable effective training.
- The government has a role to provide incentives and to reduce barriers in all these interactions.
- The government has a role to build public awareness at all levels, from school age to adult on the future of ITS and its implications.

Training for transport professionals and technicians will need to encompass a wider field of codified knowledge as well as provide skills to carry out tasks in rapidly changing systems. Training for them will also need to focus on skills to enable collaboration with skilled workers in wider fields. There will need to be an emphasis on continuous learning to address changing skills needs.

Motor trades technicians training must address the current chronic shortage of skilled technicians before attempting to target long-term skills needs. Primarily this is because future skilled workers are necessary to train future apprentices on the job. While cross-sector collaborations between industry and training organisations are currently in development, there is a need to deepen these to provide a greater emphasis on delivering apprenticeship training and to provide clear training pathways. Introduction of new technologies under ITS will necessitate action by manufacturers to provide knowledge bases on them to trainers, both in training institutions an in the workplace.

For ICT professionals and technicians, future training will need to emphasise delivery of human-centric solutions. Big data is important to ITS and the recent introduction of data science courses at tertiary institutions that link conventional computer science and statistics is an important step to provide skills to operate in big data environments. Flexible training to accommodate diverse human-centric perspectives can be achieved without formal credentials, hence the essential ICT skills are enhanced quickly and easily to enable collaboration with other fields.

Industry leadership in assessing and delivering training needs is essential. ITS firms precisely understand the current skills needs. By establishing codified learning courses in collaboration with training providers, industry can set the short-term learning agenda, from which the long-term agenda can evolve. By creating workplace learning opportunities, firms can build the absorptive capacity of their new and future workforce, so they can continually upskill as ITS implementation evolves.

## 9.7 Projections to 2035

Projections to 2035 were prepared for workers in 55 occupations, selected as relevant to ITS implementation. Baseline projections of employment, where demand for skilled workers is met by supply, for the 55 occupations were prepared. In addition projections of employment for them were developed under two future scenarios of:

- slow uptake of ITS in New Zealand
- rapid uptake of ITS in New Zealand.

Both scenarios have a higher total employment count compared with the baseline, with scenario one just over 2,200 higher and scenario four just over 7,000 higher. Both scenarios have higher employment counts for engineers, ICT and logistics occupation groups, while also having lower counts for drivers, along with repair and maintenance occupations. The latter numbers do not account for the current chronic shortage of automotive technicians and are largely driven down by the lesser employment of automotive panel beaters and body builders.

Compared with the baseline projection, which represents the current expected level of future employment, both scenarios show a greater demand for engineers to build and maintain the physical infrastructure of ITS, and ICT professionals to build and maintain the virtual infrastructure and software needed. Compared with the baseline both scenarios show less demand for drivers and for automotive panel beaters and body builders, as ITS requires fewer human drivers and will result in fewer crashes requiring repairs.

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# Appendix A: Computable general equilibrium (CGE) model

This study uses a general equilibrium model to provide measures of the base employment growth rates for the workforce model. General equilibrium models are a well-established and internationally accepted tool in the field of economic analyses and are ideally suited to providing a projected baseline of employment growth to 2035.

The fundamental premise underlying the relationships within the model is that they occur in market transactions. Indeed the model is in essence an attempt to 'mimic' the market processes in the economy over time to 2035. The market processes include the actions of market participants. One group of these market participants are workers in ITS-related occupations.

The market mechanism focuses on demands for and supplies of products and resources and the associated buyers and sellers, and workers and firms. Over time, productive resources are re-allocated so the maximum net economic benefit is obtained by the market participants. In this context economic benefit relates to firms operating at least-cost methods of production and consumers maximising their satisfaction while remaining within the constraints of their budget (income).

The general equilibrium model is an economic tool used to simulate these processes and produces empirical estimates of the changes in each market (ie the price and quantities produced and consumed of commodities) as the economy grows over time.

The particular model used here mimics the outcome of a balancing between the demands for goods and services and the resources necessary to produce those goods and services to satisfy such demands. This balancing is modelled through changes in the prices of goods, services and/or resources. The key assumptions behind this are:

- The price of a good will adjust to ensure that demand for it equals its supply. That is, if demand is greater than supply then the price of the good will rise; if supply is greater than demand then its price will decline. A similar adjustment mechanism is imposed for resources.
- At equilibrium prices there are zero pure-profits to New Zealand producers. Selling prices equate to costs of production, which incorporate rental rate on capital employed.
- New Zealand producers will endeavour to adjust their use of resources so they produce at least cost. If the price of capital rises the New Zealand producer will attempt to use more labour and less capital (per unit of output).
- Consumers (both New Zealand and foreign) will adjust their purchases towards those that are cheaper in comparison. If the price of a New Zealand-made product becomes cheaper than that of its foreign-made equivalent, both New Zealand and foreign consumers will purchase more of the New Zealand-made product and less of the foreign-made item.

The balancing is performed at the individual industry, commodity and resource level. The model separately identifies 57 industries (covering the whole of the New Zealand economy), 25 export commodities and 40 occupations. Further, the model recognises five different household classes, defined by the five quintiles of the distribution of household income and eight different consumption commodities.

The ability to adjust resource use is constrained by the prevailing technological processes within each of the 57 industries. The ability of consumers to adjust their purchases is also limited, as it is influenced by their desire to maintain preferences as well have regard to the price of them.

# Appendix B: Baseline employment counts 2015–2035 and percentage per annum change

**Table B.1 Baseline employment counts 2015–2035 and percentage per annum change**

| Occupation | Total employment counts | | | | | 2015–2035 | 1991–2015 |
|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | %pa | %pa |
| Urban and regional planner | 2,355 | 2,465 | 2,695 | 2,945 | 3,350 | 1.8% | |
| Materials engineer | 170 | 180 | 195 | 215 | 245 | 1.8% | |
| Civil engineer | 5,670 | 5,940 | 6,490 | 7,090 | 8,070 | 1.8% | |
| Geotechnical engineer | 520 | 545 | 595 | 650 | 745 | 1.8% | |
| Quantity surveyor | 2,620 | 2,745 | 3,000 | 3,275 | 3,730 | 1.8% | |
| Structural engineer | 2,935 | 3,075 | 3,360 | 3,670 | 4,180 | 1.8% | |
| Transport engineer | 1,105 | 1,160 | 1,265 | 1,385 | 1,575 | 1.8% | |
| Electrical engineer | 2,665 | 2,790 | 3,050 | 3,330 | 3,790 | 1.8% | |
| Electronics engineer | 1,065 | 1,115 | 1,215 | 1,330 | 1,515 | 1.8% | |
| Industrial engineer | 1,195 | 1,250 | 1,370 | 1,495 | 1,700 | 1.8% | |
| Mechanical engineer | 4,970 | 5,210 | 5,690 | 6,220 | 7,075 | 1.8% | |
| Engineering technologist | 225 | 235 | 260 | 280 | 320 | 1.8% | |
| Environmental engineer | 235 | 245 | 265 | 290 | 330 | 1.7% | |
| Other engineering professionals | 2,150 | 2,250 | 2,460 | 2,690 | 3,060 | 1.8% | |
| **Engineer sub total** | **27,880** | **29,205** | **31,910** | **34,865** | **39,685** | **1.8%** | **1.3%** |
| | | | | | | | |
| ICT business analyst | 560 | 580 | 630 | 685 | 775 | 1.6% | |
| Systems analyst | 12,230 | 12,745 | 13,845 | 15,040 | 17,025 | 1.7% | |
| Multimedia specialist | 290 | 300 | 325 | 355 | 400 | 1.6% | |
| Web developer | 2,665 | 2,775 | 3,015 | 3,275 | 3,705 | 1.7% | |
| Analyst programmer | 675 | 705 | 765 | 830 | 940 | 1.7% | |
| Developer programmer | 11,150 | 11,620 | 12,625 | 13,715 | 15,520 | 1.7% | |
| Software engineer | 9,750 | 10,160 | 11,040 | 11,990 | 13,570 | 1.7% | |
| Software tester | 645 | 675 | 735 | 795 | 900 | 1.7% | |
| Other software and applications programmers | 5 | 5 | 5 | 5 | 5 | 0.0% | |
| Database administrator | 3,235 | 3,370 | 3,660 | 3,975 | 4,500 | 1.7% | |
| ICT security specialist | 210 | 220 | 240 | 260 | 295 | 1.7% | |
| Systems administrator | 3,775 | 3,935 | 4,275 | 4,645 | 5,255 | 1.7% | |
| Computer network and systems engineer | 1,280 | 1,335 | 1,450 | 1,575 | 1,780 | 1.7% | |
| Network administrator | 1,090 | 1,135 | 1,230 | 1,340 | 1,515 | 1.7% | |
| Network analyst | 435 | 455 | 495 | 535 | 610 | 1.7% | |

| Occupation | Total employment counts | | | | | 2015–2035 | 1991–2015 |
|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | %pa | %pa |
| ICT quality assurance engineer | 260 | 270 | 295 | 320 | 365 | 1.7% | |
| ICT support engineer | 1,050 | 1,095 | 1,190 | 1,290 | 1,460 | 1.7% | |
| ICT systems test engineer | 860 | 895 | 970 | 1,055 | 1,195 | 1.7% | |
| Other ICT support and test engineers | 185 | 195 | 210 | 230 | 260 | 1.7% | |
| Telecommunications engineer | 835 | 870 | 945 | 1,025 | 1,160 | 1.7% | |
| Telecommunications network engineer | 840 | 880 | 955 | 1,035 | 1,170 | 1.7% | |
| **ICT sub total** | **52,025** | **54,220** | **58,900** | **63,975** | **72,405** | **1.7%** | **4.0%** |
| | | | | | | | |
| Chauffeur | 1,345 | 1,410 | 1,545 | 1,695 | 1,940 | 1.8% | |
| Taxi driver | 4,810 | 5,035 | 5,515 | 6,045 | 6,925 | 1.8% | |
| Other automobile drivers | 115 | 120 | 130 | 145 | 165 | 1.8% | |
| Bus driver | 6,145 | 6,435 | 7,050 | 7,725 | 8,850 | 1.8% | |
| Charter and tour bus driver | 485 | 510 | 560 | 610 | 700 | 1.9% | |
| Passenger coach driver | 475 | 500 | 545 | 600 | 685 | 1.8% | |
| Delivery driver | 5,185 | 5,430 | 5,950 | 6,520 | 7,465 | 1.8% | |
| Truck driver (general) | 26,360 | 27,595 | 30,240 | 33,140 | 37,955 | 1.8% | |
| Furniture removalist | 935 | 980 | 1,070 | 1,175 | 1,345 | 1.8% | |
| Tanker driver | 1,205 | 1,260 | 1,380 | 1,515 | 1,735 | 1.8% | |
| Tow truck driver | 235 | 245 | 270 | 295 | 340 | 1.9% | |
| **Driver sub total** | **47,295** | **49,520** | **54,255** | **59,465** | **68,105** | **1.8%** | **1.8%** |
| | | | | | | | |
| Automotive electrician | 1,490 | 1,565 | 1,710 | 1,870 | 2,125 | 1.8% | |
| Motor mechanic (general) | 15,370 | 16,110 | 17,615 | 19,255 | 21,865 | 1.8% | |
| Diesel motor mechanic | 2,545 | 2,670 | 2,920 | 3,190 | 3,620 | 1.8% | |
| Panelbeater | 2,960 | 3,105 | 3,390 | 3,710 | 4,210 | 1.8% | |
| Vehicle body builder | 420 | 440 | 480 | 525 | 600 | 1.8% | |
| **Repair and maintenance sub total** | **22,785** | **23,890** | **26,115** | **28,550** | **32,420** | **1.8%** | **0.9%** |
| | | | | | | | |
| Despatching and receiving clerk | 5,210 | 5,350 | 5,675 | 6,015 | 6,585 | 1.2% | |
| Import-export clerk | 1,405 | 1,440 | 1,530 | 1,620 | 1,775 | 1.2% | |
| **Logistics sub total** | **6,615** | **6,790** | **7,205** | **7,635** | **8,360** | **1.2%** | **0.7%** |
| | | | | | | | |
| Motor vehicle salesperson | 1,355 | 1,400 | 1,490 | 1,590 | 1,750 | 1.3% | |
| Automotive parts salesperson | 2,100 | 2,165 | 2,310 | 2,465 | 2,715 | 1.3% | |
| **Salesperson sub total** | **3,455** | **3,565** | **3,800** | **4,055** | **4,465** | **1.3%** | **1.4%** |
| | | | | | | | |
| **Total 55 key occupations** | **160,055** | **167,190** | **182,185** | **198,545** | **225,440** | **1.7%** | **2.1%** |

# Appendix C: Scenario one employment 2015–2035 percentage difference to baseline

**Table C.1 Scenario one employment 2015–2035 percentage difference to baseline**

| Occupation | Total employment % difference | | | |
|---|---|---|---|---|
| | 2020 | 2025 | 2030 | 2035 |
| Urban and regional planner | 0.8% | 2.0% | 3.4% | 5.1% |
| Materials engineer | 0.0% | 2.6% | 2.3% | 4.1% |
| Civil engineer | 0.7% | 2.0% | 3.4% | 5.0% |
| Geotechnical engineer | 0.9% | 2.5% | 3.8% | 4.0% |
| Quantity surveyor | 0.7% | 2.0% | 3.5% | 5.0% |
| Structural engineer | 0.7% | 2.1% | 3.4% | 4.9% |
| Transport engineer | 0.4% | 2.0% | 3.2% | 4.8% |
| Electrical engineer | 0.7% | 2.0% | 3.5% | 5.0% |
| Electronics engineer | 0.4% | 2.1% | 3.4% | 4.6% |
| Industrial engineer | 0.8% | 1.8% | 3.3% | 4.7% |
| Mechanical engineer | 0.7% | 2.0% | 3.4% | 5.0% |
| Engineering technologist | 2.1% | 1.9% | 3.6% | 4.7% |
| Environmental engineer | 0.0% | 3.8% | 3.4% | 6.1% |
| Other engineering professionals | 0.7% | 2.0% | 3.3% | 4.9% |
| **Engineer sub total** | **0.7%** | **2.0%** | **3.4%** | **4.9%** |
| | | | | |
| ICT business analyst | 0.9% | 2.4% | 2.9% | 4.5% |
| Systems analyst | 0.8% | 2.3% | 3.6% | 5.0% |
| Multimedia specialist | 1.7% | 3.1% | 2.8% | 5.0% |
| Web developer | 0.7% | 1.8% | 3.2% | 5.0% |
| Analyst programmer | 0.7% | 2.0% | 3.0% | 4.8% |
| Developer programmer | 0.8% | 2.4% | 3.6% | 5.0% |
| Software engineer | 0.8% | 2.4% | 3.7% | 5.0% |
| Software tester | 0.7% | 1.4% | 3.1% | 4.4% |
| Other software and applications programmers | 0.0% | 0.0% | 0.0% | 0.0% |
| Database administrator | 0.6% | 1.9% | 3.1% | 4.9% |
| ICT security specialist | 0.0% | 2.1% | 1.9% | 3.4% |
| Systems administrator | 0.6% | 1.9% | 3.1% | 4.9% |
| Computer network and systems engineer | 0.4% | 1.7% | 2.9% | 4.8% |
| Network administrator | 0.4% | 2.0% | 3.0% | 4.6% |
| Network analyst | 1.1% | 2.0% | 3.7% | 4.1% |
| ICT quality assurance engineer | 1.9% | 1.7% | 3.1% | 4.1% |
| ICT support engineer | 0.5% | 1.7% | 3.1% | 4.8% |
| ICT systems test engineer | 0.6% | 2.1% | 3.3% | 4.6% |

| Occupation | Total employment % difference | | | |
|---|---|---|---|---|
| | 2020 | 2025 | 2030 | 2035 |
| Other ICT support and test engineers | 0.0% | 2.4% | 2.2% | 3.8% |
| Telecommunications engineer | 0.6% | 2.1% | 3.4% | 4.7% |
| Telecommunications network engineer | 0.6% | 1.6% | 3.4% | 4.7% |
| **ICT sub total** | **0.8%** | **2.2%** | **3.4%** | **4.9%** |
| | | | | |
| Chauffeur | -0.7% | -1.9% | -3.5% | -5.4% |
| Taxi driver | -0.7% | -2.0% | -3.3% | -5.1% |
| Other automobile drivers | 0.0% | 0.0% | -3.4% | -6.1% |
| Bus driver | -0.7% | -2.0% | -3.4% | -5.0% |
| Charter and tour bus driver | -1.0% | -2.7% | -3.3% | -5.0% |
| Passenger coach driver | -1.0% | -1.8% | -3.3% | -5.1% |
| Delivery driver | -0.7% | -2.0% | -3.4% | -5.0% |
| Truck driver (general) | -0.5% | -1.8% | -3.1% | -5.0% |
| Furniture removalist | -1.0% | -1.9% | -3.4% | -5.2% |
| Tanker driver | -0.4% | -1.8% | -3.3% | -5.2% |
| Tow truck driver | 0.0% | -1.9% | -3.4% | -5.9% |
| **Driver sub total** | **-0.6%** | **-1.9%** | **-3.2%** | **-5.0%** |
| | | | | |
| Automotive electrician | 0.0% | 0.0% | 0.0% | 0.0% |
| Motor mechanic (general) | 0.0% | 0.0% | 0.0% | 0.0% |
| Diesel motor mechanic | 0.0% | 0.0% | 0.0% | 0.0% |
| Panelbeater | -0.8% | -1.9% | -3.4% | -5.1% |
| Vehicle body builder | 0.0% | -1.0% | -2.9% | -5.0% |
| **Repair and maintenance sub total** | **-0.1%** | **-0.3%** | **-0.5%** | **-0.8%** |
| | | | | |
| Despatching and receiving clerk | 0.6% | 1.7% | 3.0% | 4.9% |
| Import-export clerk | 0.7% | 1.6% | 3.1% | 4.5% |
| **Logistics sub total** | **0.6%** | **1.7%** | **3.0%** | **4.8%** |
| | | | | |
| Motor vehicle salesperson | 0.0% | 0.0% | 0.0% | 0.0% |
| Automotive parts salesperson | 0.0% | 0.0% | 0.0% | 0.0% |
| **Salesperson sub total** | **0.0%** | **0.0%** | **0.0%** | **0.0%** |
| | | | | |
| **Total 55 key occupations** | **0.2%** | **0.5%** | **0.8%** | **1.0%** |

# Appendix D: Scenario four employment 2015–2035 percentage difference to baseline

**Table D.1 Scenario four employment 2015–2035 percentage difference to baseline**

| Occupation | Total employment % difference | | | |
|---|---|---|---|---|
| | 2020 | 2025 | 2030 | 2035 |
| Urban and regional planner | 2.0% | 5.6% | 9.3% | 15.1% |
| Materials engineer | 2.8% | 5.1% | 9.3% | 14.3% |
| Civil engineer | 1.9% | 5.5% | 9.2% | 15.0% |
| Geotechnical engineer | 1.8% | 5.9% | 10.0% | 14.8% |
| Quantity surveyor | 1.8% | 5.5% | 9.3% | 14.9% |
| Structural engineer | 1.8% | 5.5% | 9.3% | 14.8% |
| Transport engineer | 1.7% | 5.5% | 9.0% | 14.9% |
| Electrical engineer | 1.8% | 5.4% | 9.3% | 14.9% |
| Electronics engineer | 1.8% | 5.8% | 9.0% | 14.9% |
| Industrial engineer | 2.0% | 5.5% | 9.4% | 15.0% |
| Mechanical engineer | 1.8% | 5.5% | 9.2% | 15.0% |
| Engineering technologist | 2.1% | 5.8% | 10.7% | 15.6% |
| Environmental engineer | 2.0% | 5.7% | 10.3% | 15.2% |
| Other engineering professionals | 2.0% | 5.5% | 9.1% | 14.9% |
| **Engineer sub total** | **1.9%** | **5.5%** | **9.3%** | **14.9%** |
| | | | | |
| ICT business analyst | 1.7% | 5.6% | 8.8% | 14.8% |
| Systems analyst | 1.9% | 5.7% | 9.2% | 15.0% |
| Multimedia specialist | 1.7% | 6.2% | 8.5% | 15.0% |
| Web developer | 1.6% | 5.1% | 8.5% | 15.0% |
| Analyst programmer | 1.4% | 4.6% | 8.4% | 14.4% |
| Developer programmer | 2.1% | 6.3% | 9.8% | 15.0% |
| Software engineer | 2.1% | 6.3% | 9.9% | 15.0% |
| Software tester | 1.5% | 4.8% | 8.8% | 14.4% |
| Other software and applications programmers | 0.0% | 0.0% | 0.0% | 0.0% |
| Database administrator | 1.9% | 5.7% | 9.4% | 15.0% |
| ICT security specialist | 2.3% | 4.2% | 7.7% | 13.6% |
| Systems administrator | 1.9% | 5.6% | 9.3% | 15.0% |
| Computer network and systems engineer | 1.5% | 4.8% | 8.3% | 14.9% |
| Network administrator | 1.8% | 5.3% | 8.2% | 14.9% |
| Network analyst | 2.2% | 5.1% | 9.3% | 13.9% |
| ICT quality assurance engineer | 1.9% | 5.1% | 9.4% | 13.7% |
| ICT support engineer | 1.4% | 5.0% | 8.5% | 14.7% |
| ICT systems test engineer | 1.7% | 5.2% | 8.5% | 14.6% |

| Occupation | Total employment % difference | | | |
|---|---|---|---|---|
| | **2020** | **2025** | **2030** | **2035** |
| Other ICT support and test engineers | 2.6% | 7.1% | 8.7% | 13.5% |
| Telecommunications engineer | 1.7% | 5.3% | 8.8% | 14.7% |
| Telecommunications network engineer | 1.7% | 4.7% | 8.7% | 15.0% |
| **ICT sub total** | **1.9%** | **5.8%** | **9.3%** | **14.9%** |
| | | | | |
| Chauffeur | -2.1% | -5.8% | -9.7% | -14.9% |
| Taxi driver | -2.1% | -5.9% | -9.8% | -15.1% |
| Other automobile drivers | -4.2% | -3.8% | -10.3% | -15.2% |
| Bus driver | -2.0% | -6.0% | -9.7% | -15.1% |
| Charter and tour bus driver | -2.0% | -6.3% | -9.0% | -15.0% |
| Passenger coach driver | -2.0% | -5.5% | -10.0% | -14.6% |
| Delivery driver | -2.0% | -6.0% | -9.7% | -15.0% |
| Truck driver (general) | -2.0% | -6.0% | -9.7% | -15.0% |
| Furniture removalist | -2.0% | -5.6% | -9.8% | -14.9% |
| Tanker driver | -2.0% | -5.8% | -9.9% | -15.0% |
| Tow truck driver | -2.0% | -5.6% | -10.2% | -16.2% |
| **Driver sub total** | **-2.0%** | **-5.9%** | **-9.7%** | **-15.0%** |
| | | | | |
| Automotive electrician | 0.0% | 0.0% | 0.0% | 0.0% |
| Motor mechanic (general) | 0.0% | 0.0% | 0.0% | 0.0% |
| Diesel motor mechanic | 0.0% | 0.0% | 0.0% | 0.0% |
| Panelbeater | -2.1% | -5.9% | -9.7% | -15.0% |
| Vehicle body builder | -2.3% | -5.2% | -9.5% | -15.0% |
| **Repair and maintenance sub total** | **-0.3%** | **-0.9%** | **-1.4%** | **-2.2%** |
| | | | | |
| Despatching and receiving clerk | 1.7% | 5.2% | 9.0% | 14.9% |
| Import-export clerk | 1.7% | 5.2% | 9.0% | 14.9% |
| **Logistics sub total** | **1.7%** | **5.2%** | **9.0%** | **14.9%** |
| | | | | |
| Motor vehicle salesperson | 0.0% | 0.0% | 0.0% | 0.0% |
| Automotive parts salesperson | 0.0% | 0.0% | 0.0% | 0.0% |
| **Salesperson sub total** | **0.0%** | **0.0%** | **0.0%** | **0.0%** |
| | | | | |
| **Total 55 key occupations** | **0.4%** | **1.2%** | **1.9%** | **3.1%** |

# Appendix E: Glossary

| | |
|---|---|
| APTA | American Public Transportation Association |
| ATAP | Auckland Transport Alignment Project |
| AV | autonomous vehicle |
| BERL | Business and Economic Research Limited |
| CERP-IoT | Cluster of European Research Projects on the Internet of Things |
| CGE | computable general equilibrium |
| CV | connected vehicle |
| CVRIA | Connected Vehicle Reference Implementation Architecture |
| DMS | database management systems |
| DoT | Department of Transportation (USA) |
| DSRC | dedicated short-range communications |
| EU | European Union |
| GIS | geographic information system(s) |
| GPS | global positioning system |
| ICT | information and communication technology |
| IM | intelligent mobility |
| IoT | internet of things |
| IPENZ | Institute of Professional Engineers New Zealand |
| ITF | International Transport Forum |
| ITP | institute of technology and polytechnic |
| ITS | intelligent transport systems |
| M2M | machine to machine |
| MaaS | mobility as a service |
| MBIE | Ministry of Business, Innovation and Employment (New Zealand) |
| MITO | MITO New Zealand Incorporated |
| MoT | Ministry of Transport (NZ) |
| MTA | Motor Trade Association |
| MVDI | Motor Vehicle Dealers Institute |
| NZQA | NZ Qualifications Authority |
| NZQF | NZ Qualifications Framework |
| OECD | Organisation for Economic Cooperation and Development |

| | |
|---|---|
| OEM | original equipment manufacturer |
| PCB | Professional Capacity Building (US programme) |
| RFID | radio frequency identification technology |
| RWIS | road weather information systems |
| SAE | Society of Automotive Engineers (US) |
| SIM | subscriber identity module |
| STEM | science, technology, engineering and mathematics |
| TSC | Transport Systems Catapult (UK) |
| V2I | vehicle to infrastructure |
| V2V | vehicle to vehicle |
| VMS | variable message signs |
| WIN | Workforce Intelligence Network for South Michigan |