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Skills gaps assessment for ITS in 2035

Julian Williams, Fiona Stokes, Hugh Dixon[1],

Douglas Wilson, Prakash Ranjitkar, Sujith Padiyara, Bevan Clement, Puti Wilson[2],

Stephen Hewett[3]

[1]Business and Economic Research Limited, BERL House, 108 The Terrace, Wellington, New Zealand

[2]Department of Civil and Environmental Engineering, University of Auckland, 22 Princes Street, Auckland, New Zealand

[3]Transport Advisory Global, Beca, 21 Pitt Street, Auckland, New Zealand

Email for correspondence: julian.williams@berl.co.nz

Abstract

This paper reports on a qualitative assessment of skills gaps likely in 2035 for New Zealand, resulting from the technological change from implementation of intelligent transport systems (ITS) in land transport. The research reported is part of a wider research project funded by the New Zealand Transport Agency, conducted in 2017 in Wellington, New Zealand. That wider project extends the research reported here by seeking to quantify the skills gaps as well as to assess future training needs. The economics and engineering literature provides important insights on the impact of technological change on skills demanded and the consequences for occupations and training. Accordingly, to develop the skills gaps assessment, we first develop scenarios of future ITS environments in New Zealand in 2035. This is informed by global literature on ITS technologies and their likely implementation by 2035. Paramount among these technologies are 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. Such development over the very long-term is expected to follow a gradual S-curve pathway characteristic of technological take up generally. The skills gaps assessment is informed by consultation with expert stakeholders from diverse fields in public and private sectors. We present the skills gaps assessment in terms of relevant well-defined occupations prevailing in 2017. Skills in the relevant occupations are expected to emerge gradually as new ITS technologies are introduced and gradually taken up. By 2035, skills gaps are expected given current expectations of future volumes and types of skills.

Disclaimers:

The views expressed herein are the views of the authors and are not attributable to the organisations to which they belong. Any errors or omissions are due entirely to the authors.

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1. Introduction

This report presents a skills gaps assessment for relevant occupations in 2035, made by expert stakeholders and informed by global and local reports, to arise from new skills demanded consequent upon the implementation of ITS technologies to land transport in New Zealand. Skills gaps assessments guide people and institutions in decisions on career options and on improving training arrangements, respectively.

To understand the impact of technological change on skills demanded, in section 2 we begin with a conceptual framework that describes skills changes as a consequence of technological change. In section 3, we outline the relevant global ITS technological environment expected in 2035, together with a selected view on the implications for skills demanded. In section 4, guided by relevant global and local global literature and with expert views, we outline five likely technology scenarios for 2035. Of these, two are selected as a context for the skills gaps assessment presented in section 5. We conclude with the main findings in section 6.

2. Conceptual framework

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.

Connected mobility outcomes in the long run, desired by society, will be achieved by continuous improvements in ITS technologies for both infrastructure and vehicles. The prevailing level of autonomy of vehicles is a defining characteristic of both that 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 as they are accepted and taken up by society.

ITS is a bundle of technologies and it is reasonable to expect that their overall uptake will follow an S-curve growth path that is an envelope of S-curve growth paths of contributing technologies. Like all individual technologies, ITS will be characterised by unique features. These unique features will determine new skills demanded for them.

Consequently, we create likely ITS technology scenarios, 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 consists of:

- understanding the relevant ITS technological change by 2035 for New Zealand
- assessing the change in skills demanded resulting from the technological change.

To understand the S-curves for potential future ITS technology scenarios, we consult global reports, local reports and local stakeholders including experts from academia; business and policy areas.

Historically, based on the work of Rogers (1962) and others, S-curves are understood to be determined by four main influencers, the innovation itself; communication channels; time; and the social system.

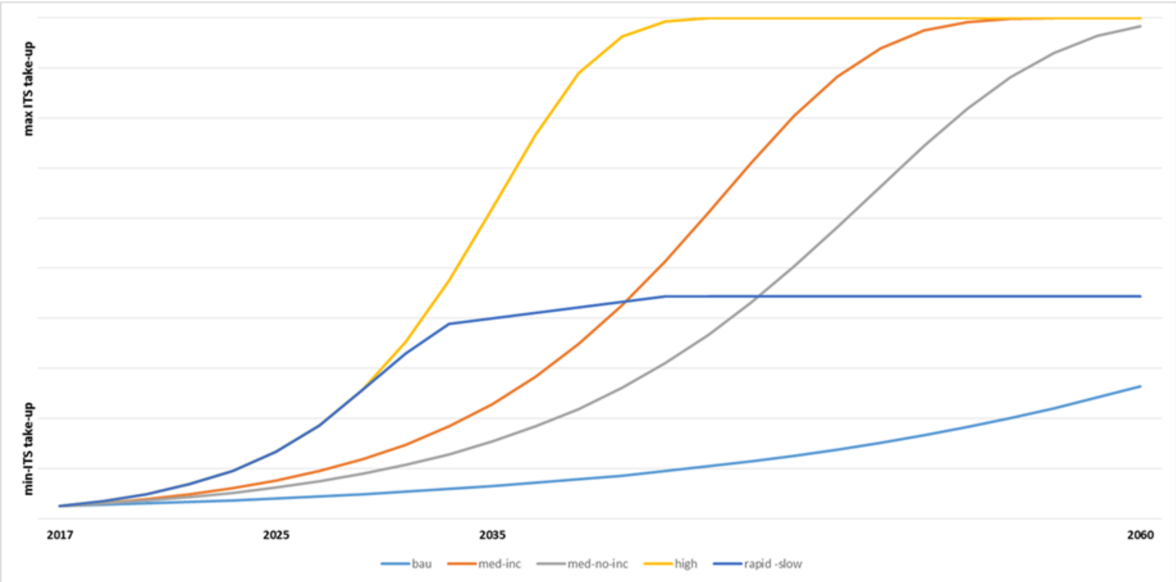
Application to this study: We express these influencers for future ITS for New Zealand in terms of the following seven factors nested within these four main influencers:

- Innovation
    - autonomy of vehicles

    - power of data analytics
    - technological support of built infrastructure
- Communication
    - Business preference
- Time
    - Period to 2035
- Social System
    - Household preference
    - Public Policy

In Figure 1, we show five potential scenarios of S-curve trajectories from the present to 2060, “the very long-term”, to illustrate likely outcomes of connected mobility in the long run.

Figure 1 Stylised S-curves for ITS scenarios to 2060 for New Zealand



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

1. Slow uptake – no enthusiasm for connected mobility by firms, households and government
2. Medium uptake with no incentives – government agencies are reluctant to invest or subsidise ITS implementation and take-up of technologies, while businesses cautiously invest
3. Medium uptake with incentives – government agencies are willing to support and invest and businesses and households cautiously support
4. Rapid uptake - firms, households and government demand connected mobility, are confident in ITS technology and the technology is available
5. 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).

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

In this study we investigate and develop a skills gaps assessment for the ITS technology change in two extreme scenarios for 2035:

- Scenario 1 slow uptake
- Scenario 4 rapid uptake.

This study is part of a wider project where we also assess training needs and estimate quantitative measures of skills gaps in terms of relevant occupation numbers at 2035.

3. Global Projections

3.1 ITS technologies - type and coverage at 2035

The range of ITS technologies in development is summarised by the CVRIA (2016) framework of the United States Department of Transport. Included in the CVRIA framework are autonomous vehicles. The autonomous vehicles literature is vast and we do not propose to include in our outline, the technologies required for their manufacture, because these technologies will have much less relevance for future skills demand in New Zealand than other ITS technologies. However, autonomous vehicle technologies are relevant to New Zealand mostly because it is likely that telematics embedded in vehicles will create demand for new goods and services that can be supplied by New Zealand firms.

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.

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.

The International Transport Forum (2015) notes that there are two incremental paths towards full automation:

- *gradually improving the automation in conventional vehicles so that human drivers can shift more of the dynamic driving task to these systems*
- *deploying vehicles without a human driver in limited contexts (such as buses in dedicated lanes) and then gradually expanding the range and conditions of their use.*

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

…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.

The International Transport Forum (2015) provides a selection of timings for when autonomous vehicles will become generally available.

IHS Automotive (2014) projects highly autonomous vehicles by 2025 and fully autonomous functionality by 2030, with autonomous vehicles 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 automated vehicles 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 of many industry leaders summarised by Truett (2016) that fully autonomous vehicles will be widely taken up only well beyond 2035.

In summary, it is likely that the implementation of ITS technologies by 2035 globally, will largely reflect the needs of semi-autonomous vehicles, but not fully autonomous vehicles. Importantly, some form of human control will be necessary for semi-autonomous vehicles.

3.2 Skills gaps to 2025 and beyond

Transport Systems Catapult (2016) launched an Intelligent Mobility Skills Strategy, informed in part by an evidence base 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 gaps 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 Table 3, from Fig 4 of the Catapult report.

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 beyond STEM with performance shaping and applied disciplines that encompass social science and creative disciplines.

Of the main findings of the report, one comment on the nature of likely skills change is that disruptive skills (high value digital skills), that will reinvent transport systems and create new businesses, are in short supply.

Table 1 Transport Systems Catapult skills categories for ITS, STEM and beyond STEM

Science, Technology, Engineering, Mathematics Basis								Societal Basis		
Infrastructure		Engineering		Physical Science		Technology Science		Social Science		Imagination
	Infrastructural Engineering	Sectoral Engineering	Science & Technology		Maths & Statistics	Computer Science	Psychology & Human Factors	Social Policy	Management	Imagination & Creativity
	Traditional Road Plans	Systems Engineering	Aeronautics			Identity & Access Management				Cross Disciplinary
	Traditional Rail Plans	Vehicle & Machine Operations	Astronautics			Cyber Security			Quality Assurance	
	Ports	Computer Aided Engineering	Marine Sciences			Systems Architecture				
	Telecomms	Quality Control				Wireless Data Comms			Project Management	Disruptive Technology
					Business Intelligence	Programme Logic Control		Education Forecasting	Standards & Regulation	
		Lean Manufacturing Value Engineering			Data Science	Simulation	Human Machine Interaction	Research Funding		
	Science Agencies	Geographical Information Systems			Analytics	Augmented/ Virtual Reality	Digital Self	Cybercrime Responses		Smart City
			Enabling Technology		Big Data	Machine Learning	Social Behaviour	Town Planning	Customer Services	
			Advanced Problem Solving		Advanced Decision Making	Artificial Intelligence	Visualisation & Perception		Town Planning	Concept

Importantly, from a training perspective, the Catapult study 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.

The Catapult study highlights the impact that data is having 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 is not 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 is fundamental.

4. New Zealand Projections

4.1 ITS technologies at 2035

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

- the Ministry of Transport report for the Auckland Transport Alignment Project (2017)
- the Synergine (2015) report

These reports indicate that it could be at least 10 years before connected autonomous vehicles start to make a significant difference to network performance. This is consistent with global views that widespread take-up of fully autonomous vehicles is decades away.

The take up of fully autonomous vehicles is a measure of the state of development of ITS technologies, since each is influential in determining the other. The ATAP report consider that 5 percent to 15 percent take up of fully autonomous vehicles is possible by 2036.

ATAP comments that if shared fully autonomous vehicles become widely adopted, the impact on public transport demand could also be material. ATAP cites research that indicates that 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).

This suggests that shared fully autonomous vehicles may provide an attractive alternative to both private vehicle travel and some public transport services – particularly those that do not experience corridor constraints or very high demand (where traditional public transport is likely to remain relatively attractive). Alternatively, fully autonomous vehicles may increase catchment areas for public transport spines by making it easier to get from home to the station.

4.2 ITS technology assessment for New Zealand at 2035

The ATAP findings and selected global literature views suggest that semi-autonomous vehicles will comprise a large part of the national vehicle fleet at 2035. With this perspective, together with learnings from global reports, and with New Zealand expert views, we assess the impact of each of the seven factors, which determine the S-curves of scenarios in section 2 above, in supporting the level of ITS technologies in the five scenarios shown in section 2. That is, we assess, for each S-curve scenario, the likely influence of each factor at 2035.

We express this impact in terms of a rating of high; medium; and low. These are shown in Table 2 and they describe vehicles and non-vehicles, where:

- for vehicles, L means SAE 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 is helpful as it provides an indication of th state of autonomy of vehicles, the readiness of society for ITS implementation, the enthusiasm of businesses, etc. In doing so it:

- provides guidance for the skills gaps 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.

Table 2 Level of ITS development by scenario and factor in 2035

Progress path scenario in the very long-term	Technologies				Transport Users		Public Policy	Connected mobility outcome in the very long-term
	Vehicles	Data Analytics	Infrastructure National	Infrastructure Local	Business	Households		
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/enthusiasm takeup, long term households more reluctant to change, barriers exist due to user convenience and cost.

1. Skills gaps assessment for New Zealand at 2035

5.1 Overview

Guided by our understanding (above) of the presence and depth of the influencing factors in the ITS technology scenarios for 2035, we develop qualitative assessments of skills gaps. 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 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.

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; and 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 for privacy, security and fraud.

Such enabling policies will lower many of the barriers for 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 and must be included when considering the impact of ITS on demand for occupations and their skills mixes.

We select two of the five ITS technology scenarios at 2035 for New Zealand, as contexts to assess skills gaps. These two extreme scenarios are:

- Scenario 1 - slow progress path
- Scenario 4 - rapid progress path

The skills gaps for the other scenarios will be some intermediate measure between these two extremes.

To develop this skills gaps assessment, we assume current prevailing occupations and skills as a starting point. We then assume a gradual change in ITS technologies, characterised by an S-curve. We then assess the likely skills needs consequent on the likely state of ITS technologies in 2035.

In making this assessment we must start with occupations, since these are known and well-defined. We then discuss an occupation as a basket of skills, so that we discuss many skills needs for an occupation. We consider skills changes will be evolutionary, particularly since the implementation of ITS technologies are likely to occur gradually in an S-curve path. We consider a varied range of skills, including generic; specific; codified; tacit; STEM; and human-centric such as from social science and creative disciplines.

Our skills gaps assessment is informed by:

- global literature, outlined above
- New Zealand specific studies, outlined above
- one on one interviews with leading stakeholders
- responses to a questionnaire sent to a wider stakeholder group
- contributions of stakeholders covering public and private sector organisations, from two workshops in Auckland and Wellington
- expert views of ITS engineering professionals on the project team.

5.2 Sales people and Inspectors

In a rapid progress scenario for vehicles, vehicle inspectors will likely be required to:

- inspect vehicles in highly complex ways, supported with technology, including online
- out-source complex assessments that can be assembled digitally and on-line.

Sales people will need on-line and real time information. Sales people will not need any special skills for this as the type of skill required is generic to many sales occupations and potentially may be acquired through on the job training.

5.3 Commercial Drivers

In slow progress scenario 1, there will be no less demand than presently for drivers, particularly heavy freight drivers. Presently, there is a shortage of heavy freight drivers.

Under rapid progress scenario 4, businesses are expected to rapidly exploit the profit opportunities from autonomous vehicles by “tethering” rigs together that:

- move in platoons over long distances
- involve a lead human driver (or driving team) followed by trailing rigs

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 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 displaces use of existing modes of transport, then fewer bus, commercial, and taxi drivers may be required.

Autonomous passenger transport has particularly important applications in low speed uncontrolled or high speed controlled areas. In addition the potential for connected journeys for passengers, will reduce the demand for public transport to and from other transport modes. As noted by the ITF[1] there are 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, etc and for connected journeys.

5.4 Personal drivers

Consumer preferences will play a large part in determining when and where consumers may wish to have connected vehicles and what digital content they consume and provide.

The preference for both connectedness of vehicles and connectedness of journeys will influence preference for 'mobility as a service' – the concept that urban travel can be consumed as a service, rather than provided through personally owned modes of transportation. Mobility as a service (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.

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, security, etc. 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.

5.5 Automotive technicians

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.

In rapid progress scenario 4, there will be an increase in the skill level of the occupation if automotive technicians need to maintain complex high technology devices connected to internal combustion power trains. If so, there would need to be a substantial change in the codified skill content, leading to a substantial change in the qualification.

However, if in this scenario, automotive technicians are limited to recording diagnostic data, which is then analysed remotely, then the essential role of the auto mechanic in maintaining an internal combustion power train remains unchanged, as would the qualification required. In this case the auto mechanic would refer the diagnostics to other skilled people, such as ICT technicians, electronic engineers, and other specialists. In some cases the referred specialist

[1] Ref above.

may be offshore, such as original equipment manufacturers (OEM), 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.

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.

5.6 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 engineer occupations possess these skills. They include 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-engineer 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.

Potentially, transport engineers with present skills can collaborate and work alongside business planning specialists in multidisciplinary teams. 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.

Importantly, most of the ITS technologies will likely involve continuously increasing emphasis on the consumer and the vehicle as an asset which: (i) generates revenue according to road use; (ii) provides real time information through telematics; (iii) 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 social science and creative disciplines. Such human-centric skills include: ethics; critical thinking; human behaviour prediction; human machine interfaces; and decision making. There will be a need for skills able to consider the interconnection of multimodal transport and provide solutions in an evolutionary way.

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.

With advent of big data and associated analytics under rapid progress scenario 4, the analysis of traffic management systems and their subsequent design and maintenance can be streamlined. This includes through the application of machine to machine (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 that there may be less need for civil construction for road maintenance. The lesser demand for professional engineers is likely to offset, in part, the greater demand for them for new types of road infrastructure occupations.

ITS infrastructure provision is often seen to involve the embedding of sensors in built infrastructure. This leads to the conclusion that demand for skilled professionals and technicians are necessary to implement and monitor them. Telematics is an important development 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 required to put it in place.

5.7 ICT personnel

Under many of the ITS progress scenarios, it is likely that skills will 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) and local (fog) solutions to analyse diagnostics from data sent from vehicles and infrastructure
- cybersecurity
- running and maintaining local machine to machine (M2M) analysis programmes
- designing human-centric interfaces for vehicles and infrastructure for local use and for offshore customers, particularly for mobility as a service (MaaS) solutions
- providing infotainment products for local consumption.

As noted by the Catapult 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, 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 are 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 occur will current technology such as with offshore data analytics, accessed through cloud computing, and connecting to analytic tools with the internet of things, in real time. ICT professionals and technicians are likely to need to manage and maintain the offshore connections, as is the case, for example, with current real time meteorological and climate information.

Then as M2M solutions are implemented globally, there will be local adoption of them in New Zealand, 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 such as where an “algorithm specialist” works 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: (i) business case assessment of outcomes and outputs required; (ii) hardware design and interface with traffic infrastructure; (iii) 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 internet of things to provide local solutions with big data networks. In this context, providers of cellular networks will require ICT professionals and technicians to establish, manage and maintain the new fog and cloud computing environment.

The implementation of driverless cars will both: (i) provide opportunities for MaaS services and (ii) 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 their passenger time.

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 simply user friendly and involves creating a solution that becomes as important, if not more important, than the travelling experience. Similar to the case for bespoke traffic management solutions, the effective provision of solutions will require a collaboration of: (i) business analysts who can assess the consumer preference and define it; (ii) electronics engineers who can provide the hardware solution; and (iii) 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 human-centric consumer preferences.

6. Conclusions

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.

We consider five potential scenarios of technological change in which these skills gaps may occur. These scenarios allow us to outline the presence, depth and complementarity of factors likely to prevail in each case which together determine skills gaps. In the context of two of these scenarios, those for slow and rapid uptake of ITS, we assess these 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 Internet of Things, 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-focussed 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.

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